FISHERY RESEARCH

JOB PERFORMANCE REPORT
PROJECT F-73-R-13

Subproject III: Lake and Reservoir Investigations
Study II: Alternate Fish Species and Strains for Fishery Development and Enhancement:
Job 1: Largemouth Bass Forage Investigations

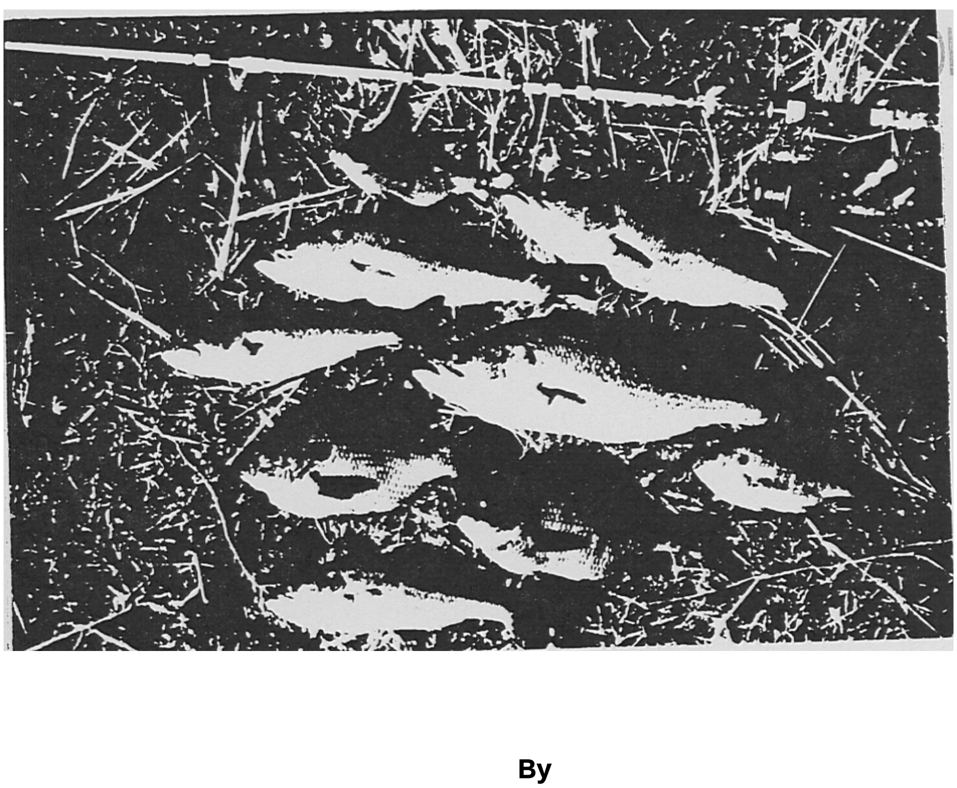

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

LIST OF APPENDICES (Cont.)

JOB PERFORMANCE REPORT

State of: Idaho

Name: Lake and Reservoir Investigations

Project No.: F-73-R-13

Title: Forage Development and Evaluation:

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Job 1: Largemouth Bass Forage Investigations

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ABSTRACT

We sampled 34 waters statewide in 1989 to 1990 to evaluate the factors affecting largemouth bass growth rates. We collected data on physical habitat, productivity, temperature, forage species composition, and largemouth bass growth and condition. Largemouth bass growth was positively correlated with mean annual air temperature. We used a bioenergetics model to examine the potential influence of temperature on largemouth bass growth within Idaho. In order to use the model, we developed a predictor of thermal regime for Idaho lakes and reservoirs based on air temperature. Indices of forage availability, generated by the model, showed no obvious relationship to forage community. Adjusting growth for temperature reduced variability among growth estimates by 40 to 45%. Temperature-adjusted growth also showed no trends related to forage. Temperature appears to be the most important factor controlling largemouth bass growth in Idaho. With the bioenergetics model, we predicted growth rates for largemouth bass in various geographical regions of Idaho. Managers can use the results to judge growth given the temperature constraints of a particular system. Managers should not rely on stocking additional prey species to substantially improve largemouth bass growth.

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INTRODUCTION

Largemouth bass *Micropterus salmoides* production and growth in some Idaho waters may be limited by forage availability. Because of this possibility, fishery managers often manipulate forage communities through introductions of new species. Managers anticipate that such introductions will improve the quality of the bass fishery through increased growth and/or survival. There is evidence that environmental constraints may limit densities of largemouth bass in some Idaho systems (Rieman 1987), suggesting that in these systems forage availability may not limit growth or survival. Fishery managers in Idaho currently have no way to decide objectively whether forage limitations for largemouth bass exist. We don't know what forage species will provide the best largemouth growth in a particular type of system. We chose to examine evidence of forage deficiency in Idaho largemouth bass populations to provide guidance for any future introductions. We selected growth and condition as the best indices of forage availability, with the recognition that factors other than forage may also influence growth.

Several biotic and abiotic factors can influence largemouth bass survival and growth. These include thermal regime (Coutant 1975; Carlander 1977; Modde and Scalet 1985, McCauley and Kilgour 1990), habitat quality (Aggus and Elliot 1975), bass density (Johnson and McCrimmon 1967), and forage availability (Miranda and Durocher 1986). Additionally, interaction between these factors may be important. An important step in documenting the need for forage manipulation is determining first that forage type does actually influence growth rates.

Temperature is likely the most important abiotic factor controlling somatic growth in fishes (McCauley and Kilgour 1990). Temperature has a clear influence on growth rates and recruitment of largemouth bass. The physiological potential for growth is positively correlated with temperature up to a maximum (McCauley and Kilgour 1990). Largemouth bass have a preferred temperature range of 24 to 28°C (Carlander 1977). Many Idaho waters reach optimum temperatures for only a few weeks each year, and some never reach optimum. Because growth is slow, bass in northern latitudes may be succeptible to predation and other mortality factors for a longer period than those found in warmer climates. Variation in year class strength is often attributed, at least in part, to spring weather. Cold fronts moving in after initiation of spawning may cause loss of the nest through abandonment or cause direct mortality of eggs or fry (Eipper 1975; Summerfeldt 1975). At northern latitudes, largemouth bass may spawn as late as July, leaving little time for young-of-the-year (YOY) bass to reach a size where they can survive the winter. Productivity of northern largemouth bass populations may also be indirectly limited by low water temperatures, which slow growth and increase the time to maturation (Rieman 1982, 1983). Our first year's data for this project (Dillon 1990) indicated that mean annual air temperature is positively correlated with largemouth bass growth within Idaho.

Because the influence of temperature on growth is so important, we must account for differences in thermal regime to determine whether growth is also influenced by other factors, including forage. Recently developed bioenergetics models are excellent tools to examine the effects of temperature and forage availability on fish growth. The Wisconsin Model (Hewett and Johnson 1987) is applicable for many species including largemouth bass. The model documentation provides the required physiological parameters for several species. Most applications of bioenergetics models have focused on predicting total consumption by a predator population based on population size, temperature, and growth (Stewart et al. 1983; Rice and Cochran 1984; Carline 1987). One can also use the model to examine the potential effects of temperature on growth while holding other parameters constant (Hill and Magnuson 1990). If growth (weight at age) and temperature regime are known, the model can calculate indices of forage availability (p-values) for individual age classes of a predator population. With known p-values, the investigator can then change the thermal regime to examine the effects of temperature on growth. To investigate the influence of other factors on growth, one can set all study waters to the same thermal regime, thereby removing the influence of temperature from the growth data.

Other environmental factors can also influence largemouth bass productivity and growth. Basin morphometry as it relates to littoral development and vegetative cover determines both the available habitat and the available spawning area for a given water. Percent and type of vegetative cover has important influences on predator-prey interactions and foraging efficiency (Savino and Stein 1982). Morphometry also influences the thermal regime within a system. Broad shallow waters warm faster than deeper waters, promoting earlier spawning and a longer growing season. In the irrigation reservoirs of southern Idaho, water level fluctuation, especially summer drawdown, may have dramatic influences on spawning success and availability of macrophyte cover, directly affecting recruitment and predator-prey interactions (Keith 1975; Ploskey 1986).

Lake productivity and zooplankton abundance may influence YOY bass growth and survival. Conversely, where environmental constraints (spring weather or available spawning habitat) limits survival of YOY bass, productivity and zooplankton abundance is less likely to influence recruitment.

In many instances, largemouth bass growth has shown an inverse relationship with density, suggesting intraspecific competition for available forage resources (Ming and McDannold 1975). Bowles (1985) found that growth and survival of YOY largemouth bass in several north Idaho lakes were positively correlated with abundance, suggesting no forage limitation for YOY in these systems. Rieman (1987) also found no evidence of density-dependent growth in largemouth bass in eight north Idaho lakes, and speculated that irregular recruitment may prevent populations from reaching levels where density-dependent effects are evident. No other studies relating largemouth population density to growth have been conducted in Idaho.

The ability to predict and increase largemouth bass growth by use of forage fish is the prime interest of managers. If we can describe associations of prey species which provide better growth than others for a particular type of system, it may help the selection of the best species for forage enhancement. This information would also be useful in efforts to establish largemouth bass fisheries in new or renovated waters. Providing forage species that improve or maximize growth should translate to better bass survival and faster recruitment to the fishery. Conversely, if factors other than forage are most limiting to largemouth bass growth in Idaho, then the risk and effort involved in new species introductions can be avoided.

OBJECTIVES

1) Describe the range of growth for largemouth bass in Idaho.

2) Develop methods to predict thermal regime in Idaho waters; describe the influence of temperature on largemouth bass growth within Idaho.

3) Quantify the influence of productivity, habitat, and forage species composition on largemouth bass growth in Idaho. Identify patterns of growth related to forage and characteristics of waters associated with good growth and trophy potential for largemouth bass.

METHODS

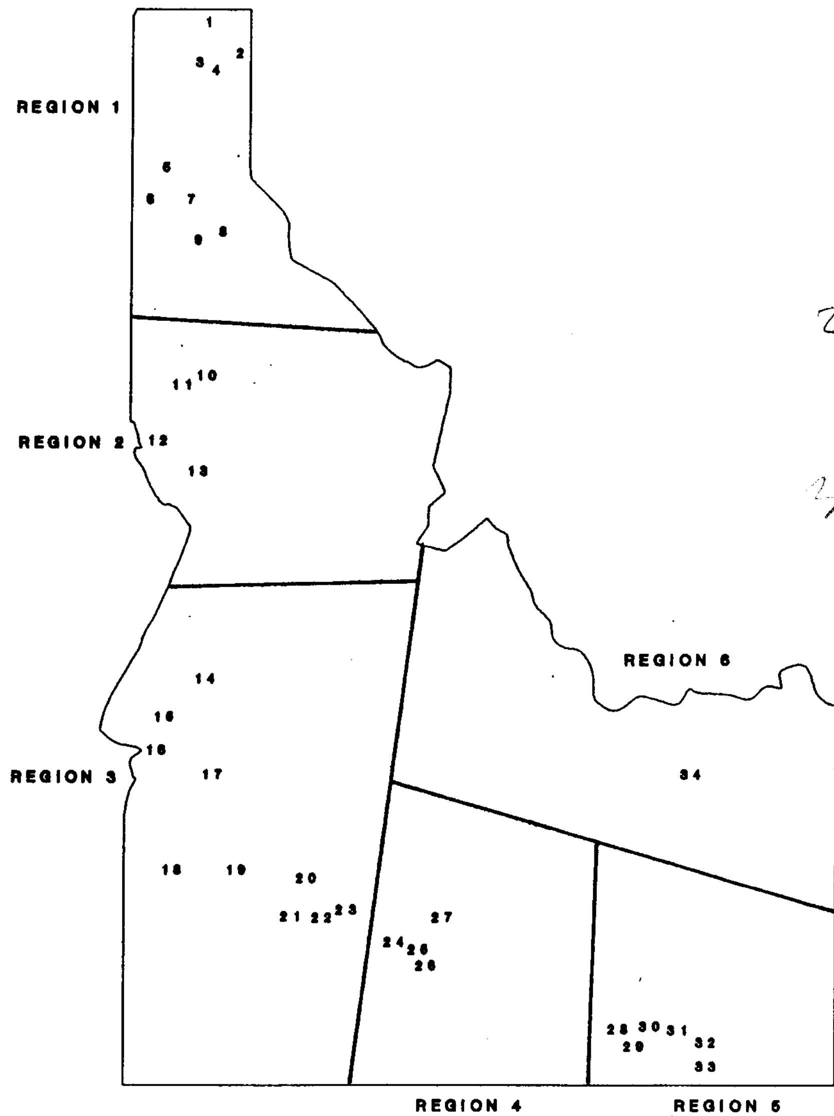
Study Area

To examine fully the factors that might influence largemouth bass growth in Idaho, we tried to account for as many biotic and abiotic factors as possible in our sampling. We sampled waters throughout Idaho in 1989 and 1990 to provide as much variability in the data set as possible. Lakes and reservoirs sampled are presented in Figure 1.

Sampling Strategies

Data collected for each study water were:

1) Surface area at full pool.
2) Total dissolved solids (TDS) and conductivity.
3) Mean depth at full pool.
4) Morphoedaphic index (MEI).
5) Mean shoreline slope at water interface.
6) Percent area covered by vegetation (aquatic macrophytes and emergent).
7) Percent of littoral zone with vegetative cover.
8) Percent aquatic macrophyte cover (area).
9) Percent of littoral zone with downed timber cover.
10) Percent of littoral zone with flooded terrestrial vegetation.
11) Percent of littoral zone with boulder cover.
12) Stable or fluctuating water level.
13) LMB catch rate by electrofishing.
14) LMB proportional stock density (PSD).



1. Robinson L. (ROB)
2. Perkins L. (PER)
3. Dawson L. (DAW)
4. Smith L. (SMI)
5. Upper Twin L. (UPT)
6. Hauser L. (HAU)
7. Fernan L. (FER)
8. Blue L. (BLU)
9. Black L. (BLK)
10. Moose Creek Res. (MCR)
11. Spring Valley Res. (SPV)
12. Mann L. (MAL)
13. Winchester L. (WNC)
14. C. Ben Ross Res. (CBR)
15. Mann Creek Res. (MAC)
16. Henning's Pond (HEN)
17. Paddock Res. (PAD)
18. Lake Lowell (LOW)
19. Indian Creek Res. (ICR)
20. Morrow Res. (MOR)
21. C.J. Strike Res., Bruneau arm (CJB)
22. Crane Falls Res. (CFR)
23. Sand Dunes Lake (SDL)
24. Lower Salmon Dam (LSD)
25. Hagerman W. Hwy 30 Pond (HAG)
26. Sumner Gravel Pond (SUM)
27. Dog Creek Res. (DOC)
28. Pleasantview Res. (PLV)
29. St. John's Res. (STJ)
30. Deep Creek Res. (DEC)
31. Twin Lakes (TWL)
32. Winder Res. (WIN)
33. Condle Res. (CON)
34. Mud Lake (MUD)

Figure 1. Locations of largemouth bass lakes and reservoirs sampled in 1989-1990. Idaho Department of Fish and Game regional boundaries are shown for reference to geographical data summaries in subsequent figures. Abbreviations () used in subsequent figures.

15) LMB relative weights.
16) Mean annual air temperature at the nearest climatological recording station.
17) Elevation.
18) LMB age at 200, 300, and 400 mm as an index of growth rate.
19) Species composition by presence or absence.

When not available in existing reports or files, we collected data in the field or through other sources. We measured surface area with a planimeter using USGS maps. We measured conductivity with a digital conductivity meter at five open-water sites in each system and averaged the values. We estimated values for TDS from the conductivity data. We estimated mean depth at full pool using existing morphometric maps or by obtaining storage volume data from irrigation companies and dividing by surface area. We calculated morphoedaphic indices TDS/mean depth (m). We measured mean shoreline slope and cover type by shoreline transects with visual estimations at approximately 100-m intervals. In large waters, we used systematic subsampling. We either visually estimated percent aquatic macrophyte cover (area) or sketched the vegetative cover on a map and later measured it with a planimeter. For each water, we noted whether it was subject to drawdown or if water levels were stable.

In waters where largemouth bass growth data were lacking, we collected bass by electrofishing. We based catch rates in each water on a minimum of three 20-minute efforts, or until we had sampled the entire shoreline. All bass were measured (total length (TL) to the nearest 10 mm) and weighed (g). We used clear plexiglass tubes to extract the stomach contents of some bass for a cursory examination of diet. Catch rates for each effort were extrapolated to number of fish per hour, and the results averaged for each water. Our goal was to sample at least 30 bass >250 mm from each water. Previous work showed that scale samples from 25 to 30 largemouth bass are sufficient to detect a 10% difference in growth among systems (Dillon 1989).

We calculated largemouth bass PSD (Anderson 1976) and relative weights (Wr) (Anderson and Gutreuter 1983) for each water.

We obtained mean annual air temperature data from the National Climatic Data Center publications for Idaho. We used data from the climatological recording station nearest each water. If the elevation of the nearest station was more than 150 m higher or lower than the study water, we used data from a nearby station at an elevation closer to that of the study water. We obtained elevations from a variety of sources, primarily USGS maps and existing reports.

We estimated species composition in each water by combining the electrofishing catch with that from gill net and trap net efforts. Previous work showed that species composition is best estimated by using a variety of sampling gears (Dillon 1989). In each water, we set two 15.2-m x 1.2-m small mesh (9.5-mm) gillnets, two 38.1-m experimental gillnets (7.6-m panels of 2.5-, 5.1-, 7.6-, 10.2-, and 12.7-cm square mesh), and two South Dakota baby-frame trap nets (6.4 mm mesh) for one night. In general, we used one of each gear type on opposite sides of the water. We sorted and counted fish by species.

Largemouth Bass Growth and Condition

We made scale impressions on acetate slides and aged and measured impressions on a microfiche projector. At least two persons aged each scale independently. When age determinations disagreed, we reexamined the scale. If the difference could not be resolved, we did not use the scale for back-calculation. We back-calculated length-at-annulus using the proportional method with the standard intercept of 20 mm (Carlander 1982). After measuring all scales, we remeasured 25% of the scales from each water for verification. For comparisons of growth among waters, we converted length-at-age data to age-at-length for 200, 300, and 400 mm. We interpolated from growth increments of individuals to estimate age-at-length. For example, if a fish was 150 mm at age 2 and 250 mm at age 3, we estimated that it reached 200 mm at age 2.5. This allowed us to design sampling goals based on fish size (minimum 250 mm) rather than relying on capturing fish of a specified age class in each water. It also allowed a simpler description of the range in growth than comparisons of length-at-age for all age classes sampled.

We compared mean Wr values for largemouth bass <300 mm and >300 mm to look for evidence of size-specific forage limitation.

Evaluation of Factors Influencing Growth

Preliminary Analyses

To assess the influence of environmental factors on largemouth bass growth, I first ran a correlation analysis of all variables except forage species composition. Environmental variables showing a strong correlation with age-at-length were used in regression analyses with age-at-length as the dependent variable (Steele and Torrie 1980). Results showed a strong correlation between mean annual air temperature and bass growth. It was necessary, therefore, to remove the effects of temperature from the growth data to more reliably detect differences in growth related to other variables, including forage.

Water Temperature and Growth

To examine the relative influence of temperature on growth, I needed to estimate the thermal regime in each study water. I obtained water temperature data from two north Idaho lakes, Fernan (1981) and Blue (1982) (Rieman 1982, 1983), and the corresponding year's air temperature for Coeur d'Alene. I built a predictor of water temperature based on air temperature using the methods of Hill and Magnuson (1990). The predictor used the current month's mean air temperature (ATC), the previous month's mean air temperature (ATP), and the previous month's mean water temperature (WTP) to predict the current month's mean water temperature (WTC). The best model was:

$$WTC = 1.768 + (.784)ATC + (.292)WTP - (.098)ATP \quad R^2 = .96$$

The predictor is iterative, using results for one month in the subsequent calculation.

I used 30-year mean monthly air temperature data from the recording station nearest each study water to predict the annual thermal regime for each water. I assumed minimum water temperatures to be 4°C, and predicted each initial month's (January) water temperature based on a December water temperature of 4°C and the January air temperature. I assumed the minimum winter water temperature (under ice cover) to be 4°C. If the predicted water temperature was below 4°C, I substituted 4°C for the predicted value in the following bioenergetics analyses. I also assumed that largemouth bass would select the maximum available water temperature, as predicted by the model, throughout the year.

Bioenergetics analyses followed closely the methods of Hill and Magnuson (1990). It is important to note that alternative respiration parameters for largemouth bass have been proposed for low temperatures typical of our lakes. The new RA value is 0.00279, and the new RQ value is 0.0811 (Barry Johnson, personal communication to Bruce Rieman). With the above changes, we followed the model documentation of Hewett and Johnson (1987). I did not include spawning losses in my analyses.

I used a graphical representation of the bass length-weight relationship for each water to estimate weight-at-age for all age classes present. For waters where length-weight data were lacking, I estimated weight-at-age using the growth data and standard weights. I used the weight-at-age and thermal regime data in the Wisconsin Model to calculate indices of forage availability (p-values) for individual cohorts in each water, holding other model parameters constant (Hill and Magnuson 1990). The p-value represents the proportion of actual growth to potential growth at a given temperature if forage was unlimited, and is considered an index of forage availability (Hewett and Johnson 1987).

I compared mean p-values for each population to forage species presence or absence to look for evidence of changes in forage availability with forage type.

I then set all waters to the maximum Idaho thermal regime (that in the Bruneau area) estimated by the water temperature predictor. With known p-values for cohorts of each population, I used the model to recalculate weight-at-age based on the adjusted thermal regime. I was unable to adjust growth to age 1 because the initial age 0 weight was unknown. I used the estimated weight at age 1 for each water in the model to calculate adjusted weight at age 2, and so on for all cohorts. I used either the length-weight relationship or standard weight values to estimate temperature-adjusted length-at-age for largemouth bass in each water. I converted length-at-age data to age-at-length as above for graphical comparisons and further analysis.

I reran the correlation analysis of all variables except forage using the temperature-adjusted growth data.

Multivariate Analyses

I ran separate principal components analyses on both the habitat and species composition data. I designate species presence/absence by 1 or 0, respectively, in the data base.

We attempted to use discriminant analysis to identify the factors associated with poor, moderate, and good largemouth bass growth. We subjectively assigned waters to growth categories using both observed and temperature-adjusted growth data. Independent data were tested for normality using Lillefor's test (Tom McArthur, Idaho Department of Fish and Game, personal communication). We used standard data transformations to meet the assumptions of discriminant analysis. Prior to the discriminant analyses, we performed univariate and multivariate analyses of variance to detect differences in lake characteristics among growth categories. We also ran correlation analyses for both observed and temperature-adjusted growth groups using the transformed data set. Results from the correlation analyses indicated that discriminant analysis would be of little value.

Patterns of Largemouth Bass Growth

The above analyses indicated that temperature accounts for much of the variability in bass growth within Idaho. It would be useful to describe the range of growth expected for largemouth bass in the various areas of the state to give better perspective on individual waters. To do this, I estimated length at age for largemouth bass in several geographic areas. I used the predicted water temperature regime for each area and the statewide average p-values for each cohort from our data. With this, the biologists may compare actual bass growth data to the potential growth curve for their area.

RESULTS

A complete summary of the data collected on all study waters is provided in Appendices A and B.

Largemouth Bass Growth and Condition

Mean lengths-at-age for largemouth bass from each study water are presented in Appendix C. Mean age at 200 mm ranged from 1.4 to 4.1 years, mean age at 300 mm from 2.7 to 7.3 years, and mean age at 400 mm from 4.3 to 9.7 years (Figures 2, 3, and 4).

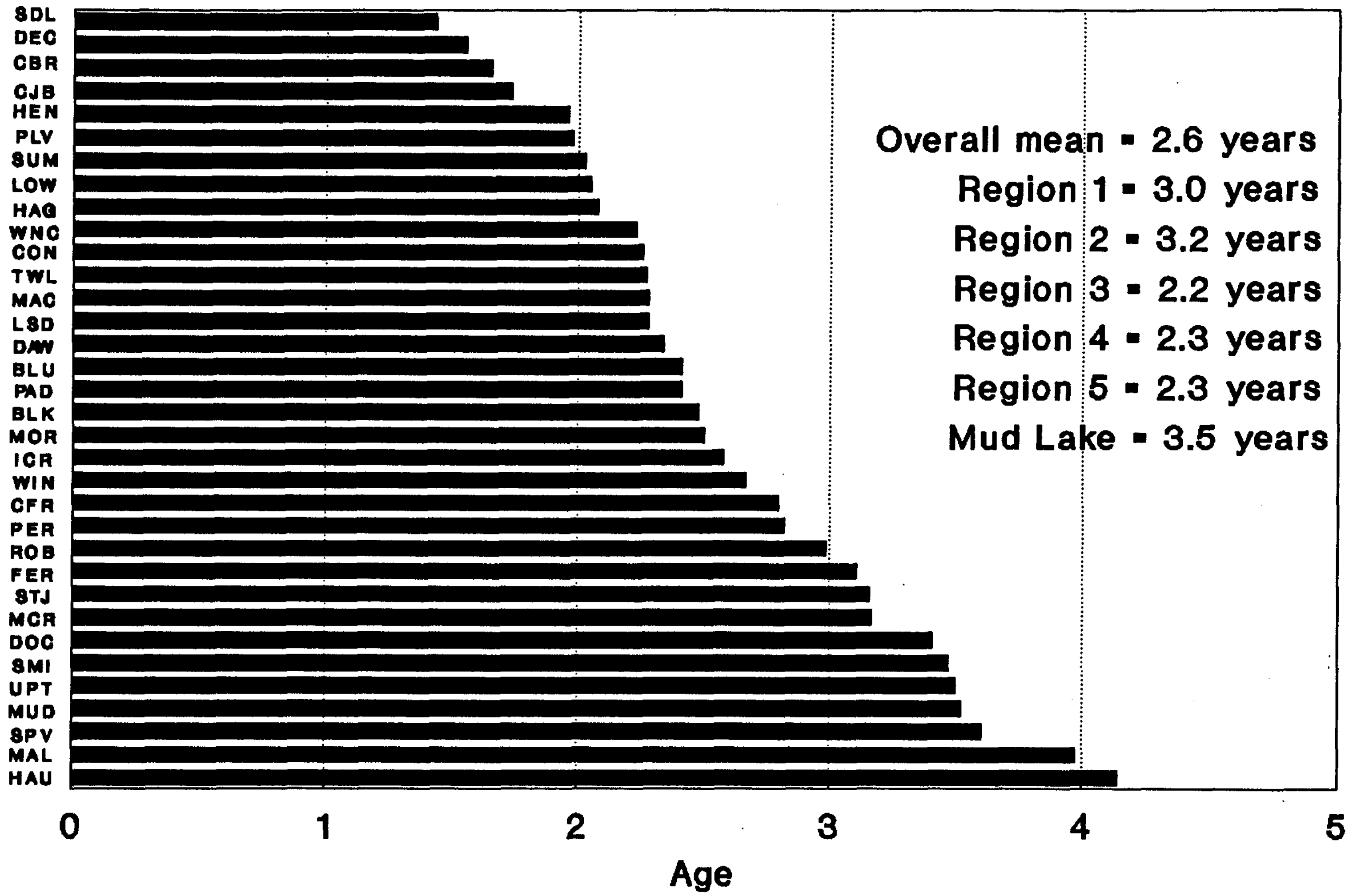


Figure 2. Mean age at 200 mm for Idaho largemouth bass populations sampled statewide, 1989-1990.

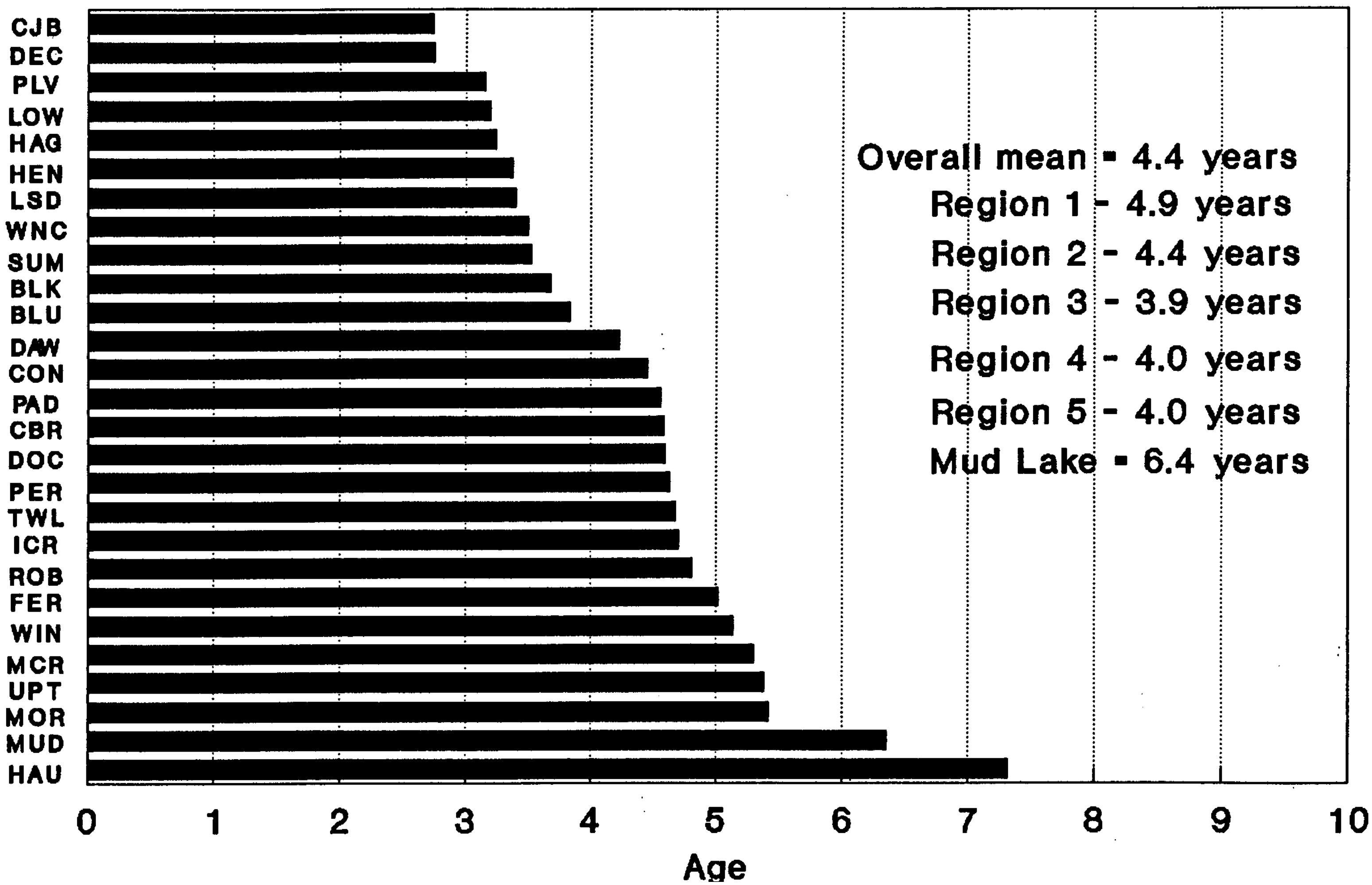


Figure 3. Mean age at 300 mm for Idaho largemouth bass populations sampled statewide, 1989-1990.

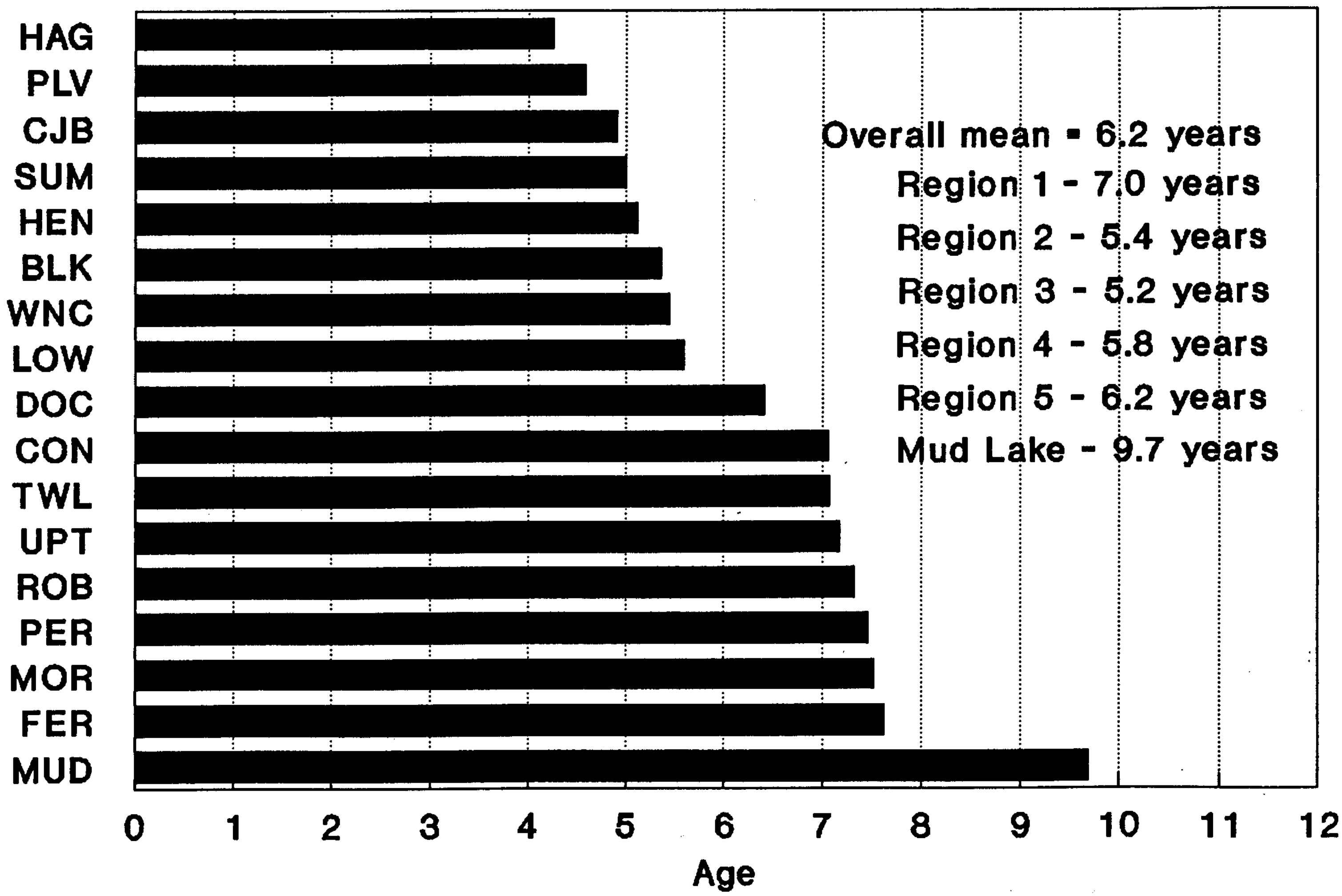


Figure 4. Mean age at 400 mm for Idaho largemouth bass populations sampled statewide, 1989-1990.

Relative weights in most waters were at or above 100 for <300 mm and >300 mm size classes of bass (Appendix B). We found no significant correlation between Wr and age-at-length for waters with Wr data available.

Evaluation of Factors Influencing Growth

Preliminary Analyses

For variables other than forage, conductivity and mean annual air temperature had the strongest correlation with largemouth bass growth (Appendix D). Regression analyses indicated that these two variables accounted for 56% of the variability in age at 400 mm, but considerably less at the smaller sizes (Appendix E).

Water Temperature and Growth

Predicted thermal regimes for each study water are presented in Appendix F. With an initial (December) water temperature input of 4°C, the model tended to predict water temperatures below 4°C in the winter months. Predicted maximum mean monthly water temperatures ranged from 18.3°C at Winchester Lake to 25.0°C for the Bruneau area waters.

Indices of forage availability (p-values) for individual largemouth bass cohorts in each water are presented in Appendix G. P-values tended to decline with increasing fish age. There was no apparent trend between population mean p-values and forage species composition (Figure 5). Forage availability for bass in these waters did not appear related to species composition.

Temperature-adjusted length-at-age for largemouth bass in each study water is presented in Appendix H. For the adjusted data, the range of age at 200 mm was 1.5 to 3.7 years; age at 300 mm, 1.8 to 5.6 years; and age at 400 mm, 2.7 to 7.1 years (Figures 6, 7, and 8). Adjusting for temperature increased growth in most waters and decreased the range of growth across all populations.

Correlation Analysis with Temperature-Adjusted Growth

With largemouth bass growth rates adjusted for temperature, correlation analysis revealed no environmental variables associated with growth. Conductivity, which appeared correlated with bass growth using unadjusted data, was also weakly correlated with temperature (Appendix D). The colder waters of north Idaho generally had lower conductivity than the warmer southern waters.

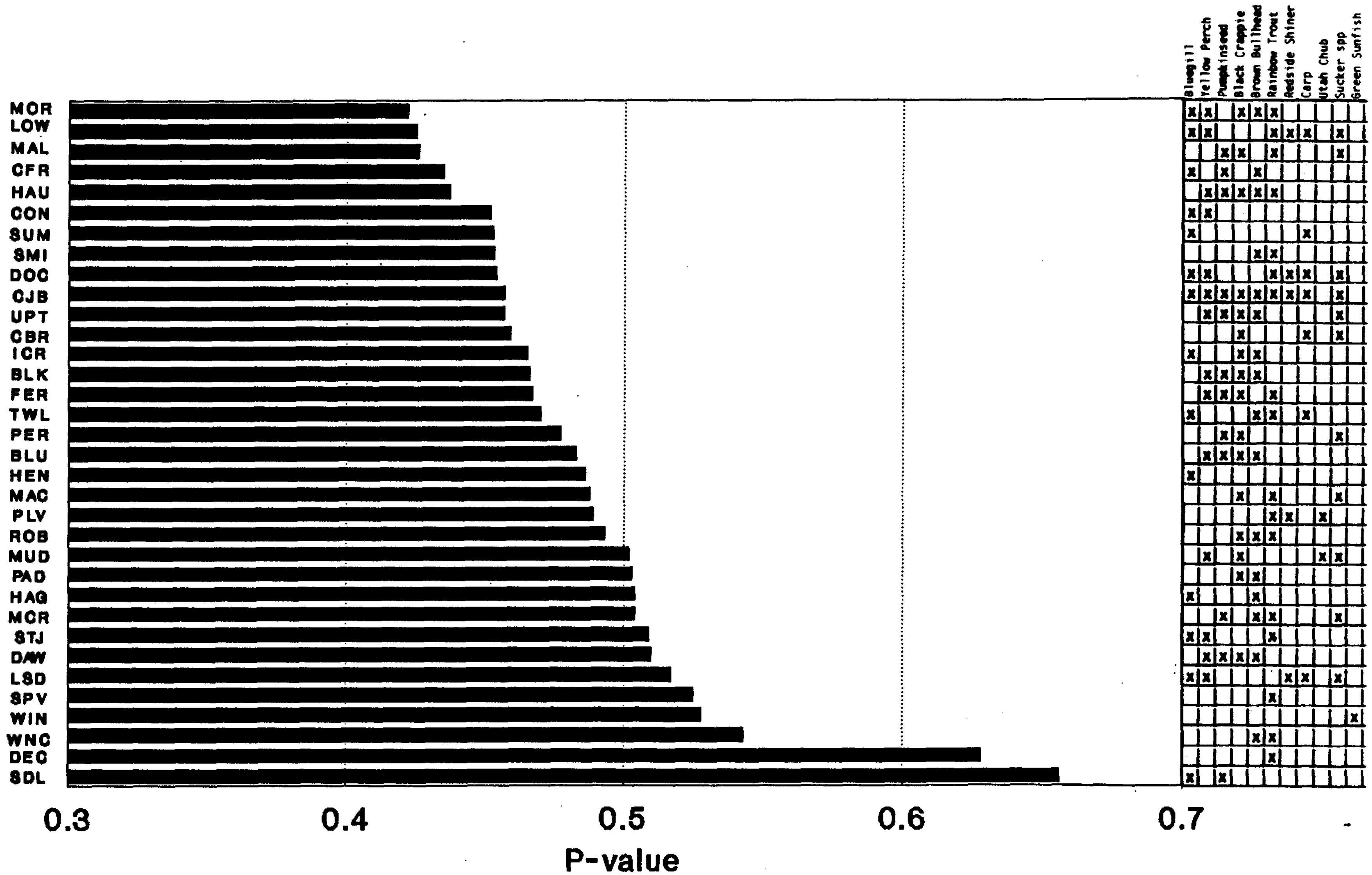


Figure 5. Indices of forage availability (p-values) for Idaho largemouth bass populations sampled, 1989-1990, and associated forage species.

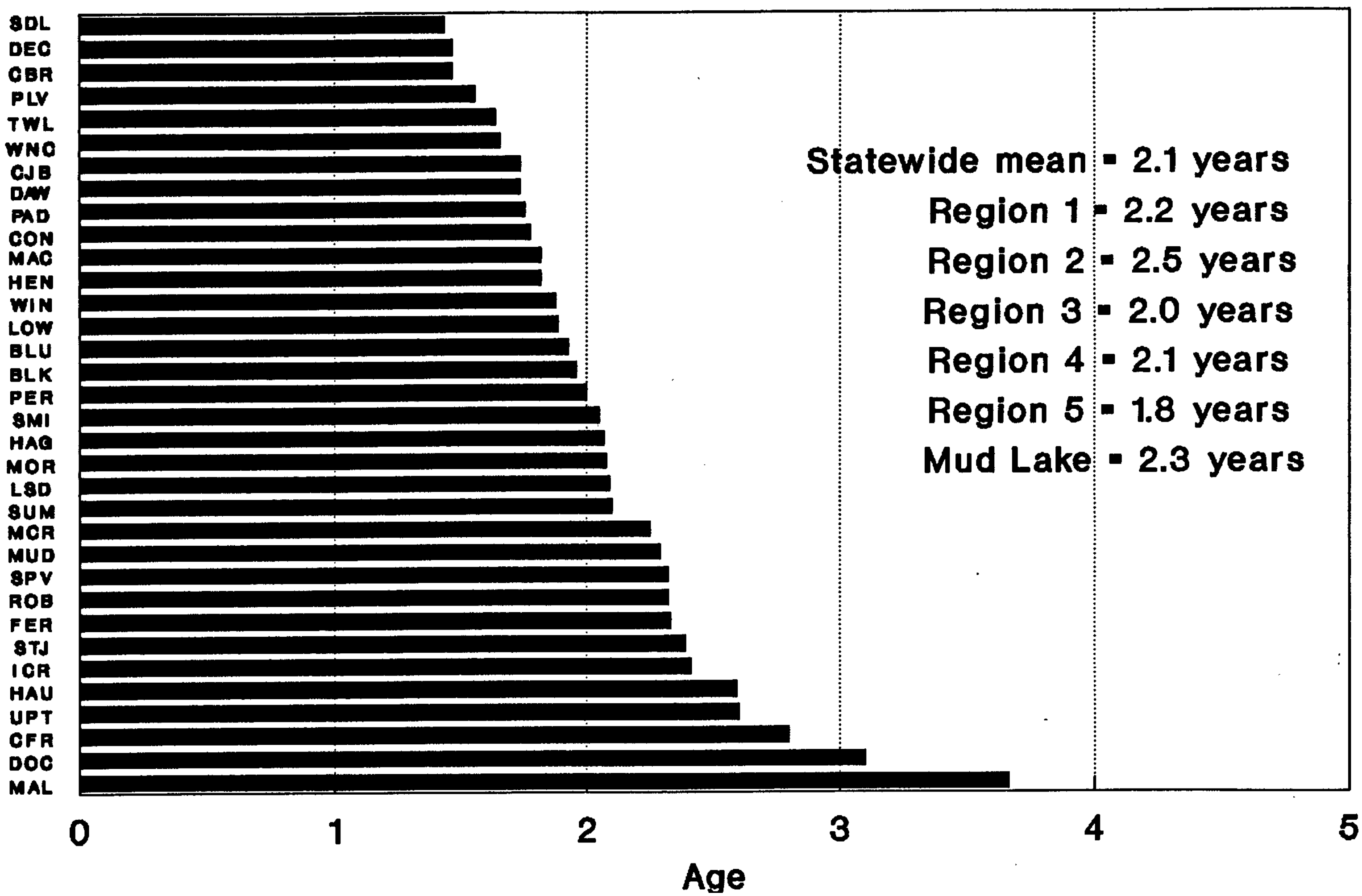


Figure 6. Temperature-adjusted age at 200 mm for Idaho largemouth bass populations sampled, 1989-1990.

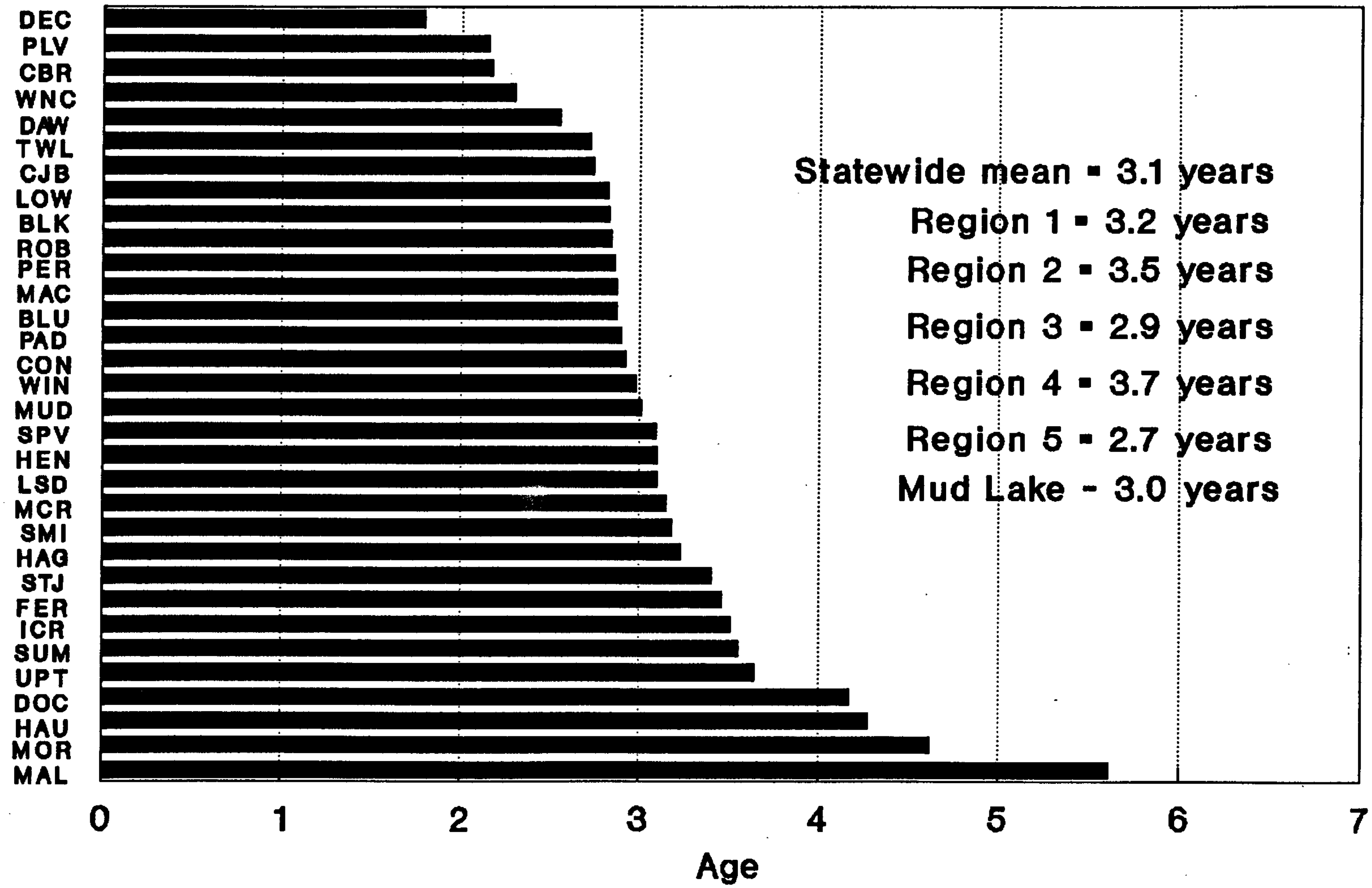


Figure 7. Temperature-adjusted age at 300 mm for Idaho largemouth bass populations sampled, 1989-1990.

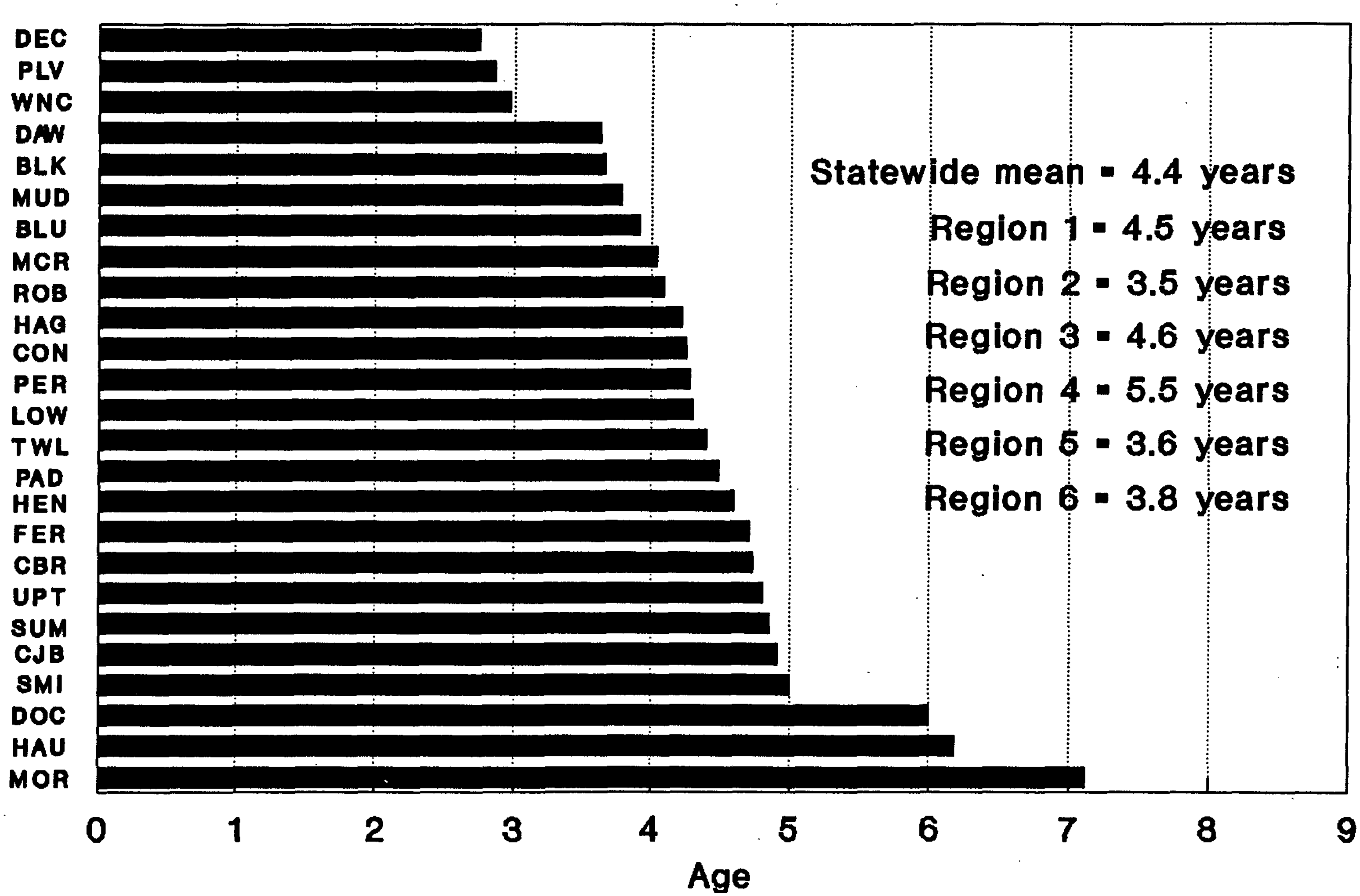


Figure 8. Temperature-adjusted age at 400 mm for Idaho largemouth bass populations sampled, 1989-1990.

Multivariate Analyses

With transformed data, the univariate and multivariate analyses of variance indicated that the only independent variable consistently significant was log (conductivity). Log (conductivity) showed a positive relationship with both observed and temperature-adjusted growth. The correlation analyses by group showed many correlations were inconsistent in both sign and magnitude among groups. This indicated that discriminant analysis would not be useful to describe lake characteristics associated with largemouth bass growth.

We are pursuing a more complete analysis of the data through the Utah State University College of Natural Resources. The results of this analysis will be submitted at a later date as an addendum to this report.

Patterns of Largemouth Bass Growth

Forage species composition did not have a clear influence on forage availability or our samples of bass growth. Plots of expected growth in various parts of the state, based on regional temperature and statewide average p-values (Appendix G), are presented in Appendix I.

DISCUSSION

The wide range of largemouth bass growth rates seen in Idaho reflects the diversity of systems found in the state. In general, the colder waters of northern Idaho had poorer largemouth bass growth than the warmer southern waters.

The use of the bioenergetics model allowed more meaningful comparisons of largemouth bass growth among systems by removing the effects of temperature from the data. Our predictor of thermal regime for individual waters may not be exact, but it did allow us to evaluate the relative influence of temperature on bass growth within Idaho. Hill and Magnuson (1990) found that the mathematical relationship between air and water temperature differed with season and location in the Great Lakes region. Our data set was too small to develop separate seasonal predictors of water temperature. It would be useful to obtain annual temperature data for more waters around the state to validate or improve the predictor. Hill and Magnuson (1990) used 20 years of air and water temperature data to develop their predictors of thermal regime for three areas of the Great Lakes. Accurate temperature data should be considered vital when comparing fish growth over a broad geographical range.

Several of the largemouth bass populations investigated showed exceptionally poor or good growth even after compensating for temperature. These show up as extremes in our temperature-adjusted growth data (Figures 6, 7, 8). Slower than expected growth could be related to several factors, including poor water quality, poor habitat quality, or competition. Mann Lake had a high density of 120 to 240 mm bass and no littoral habitat. Crane Falls Reservoir had a high density of 250 to 280 mm bass and a bluegill PSD of 96, suggesting an out-of-balance predator-prey community (Anderson and Gutreuter 1983). Morrow and Indian Creek reservoirs were extremely turbid, possibly affecting foraging efficiency of bass. Better than expected adjusted growth in Pleasantview Reservoir is likely related to a warm spring inflow, resulting in an underestimate of its thermal regime and a consequent overestimate of forage availability from the bioenergetics analysis. Exceptionally good bass growth in Winchester Lake may be related to heavy stocking of fingerling rainbow trout (1,050 fish/hectare) which are apparently the primary forage for bass in the lake (Ed Schriever, Idaho Department of Fish and Game, personal communication).

Adjusting for temperature did not decrease the overall variability of our growth data. However, with the above outliers deleted, adjusting for temperature did reduce growth variability by about 40-45% (Appendix J). Temperature accounts for nearly half of the variability in largemouth bass growth across Idaho.

With the effects of temperature removed, forage species composition did not have a clear influence on bass growth. This indicates that forage type is not an important limitation to largemouth bass fisheries in Idaho. Deep Creek Reservoir had no forage fish, but growth to 300 mm was the second best found in the state. This population resulted from an unauthorized introduction of largemouth bass in 1985 or 1986 (Dan Schill, Idaho Department of Fish and Game, personal communication), and the population is probably expanding. Cursory examination of stomach contents showed that the bass were feeding extensively on leeches. Growth data indicate that the 1987 year class is growing considerably slower than the 1986 year class (Appendix K). Competition may be beginning to limit bass growth in this system.

Our catch rate data is probably not directly comparable because we sampled the waters over several months. Still, the data suggest that bass density among similar system types may affect growth rates. Hauser Lake had the slowest largemouth bass growth of all Idaho waters sampled. Hauser has a very diverse forage base, but is relatively unproductive. Largemouth bass catch rates in Hauser were higher (78 fish/h) than in similar nearby waters with diverse species compositions (Upper Twin, 26/h; Blue Lake, 36/h; Black Lake, 43/h) (Appendix B). Growth rates in these other waters were considerably better than in Hauser. Largemouth bass in the Bruneau Sand Dunes pond were reestablished in 1987. Bass catch rates here were lower (50 fish/h) than in nearby Crane Falls Reservoir (113 fish/h), and growth of the new recruits was better, despite a similar forage base (Appendix B). While inconclusive, it may be important to conduct population or biomass estimates for largemouth bass in several system types around the state to document differences in density to predict where density-dependent growth is likely to occur. Competition is more likely to be a factor in southern Idaho waters where environmental constraints are less apt to limit recruitment. Competition may also be more important now than in the past with the initiation of the statewide 305 mm minimum length for largemouth bass.

Because temperature is the most important factor affecting largemouth bass growth in Idaho, managers should not expect forage introductions to provide substantial benefits. When establishing largemouth bass fisheries in new or renovated waters, selection of a forage species should depend more on environmental constraints, population characteristics, and fishery potential of the forage species.

The use of bluegill as largemouth bass forage in the colder and more sterile waters of north Idaho should be viewed with caution. Previous work predicts that the value of bluegill as largemouth bass forage declines at northern latitudes (Modde and Scalet 1985). Modde and Scalet (1985) found that the differences in growth related to latitude were more pronounced in largemouth bass than in bluegill. This decreases the susceptibility of bluegill to bass predation and can lead to overpopulation and stunting of bluegill. When largemouth bass densities are regulated by environment, their ability to "control" forage species decreases and the chance for developing an out-of-balance predator-prey system increases (D.W. Willis, South Dakota State University, personal communication). Howard Snow (Wisconsin Department of Natural Resources, personal communication) reported that stunted bluegill are the primary fisheries problem in northwestern Wisconsin. He attributes the problems to insufficient predation pressure from largemouth bass. These waters are similar in productivity, and probably temperature, to north Idaho lakes. Where macrophyte cover is over 30% of surface area, bluegill are also less succeptible to predation and tend to stunt (Colle and Shireman 1980).

Bluegill were introduced to five north Idaho lakes in 1989. Restriction of further north Idaho bluegill introductions to waters with relatively high bass densities and macrophyte cover less than 30% is suggested. Restrictive harvests on bass (length limits or catch-and-release) to keep bass densities high could help keep bluegill from stunting. It may be advisable to curtail further introductions of bluegill to north Idaho until we can evaluate the recent introductions.

Our data showed no relationship between reservoir drawdown and largemouth bass growth. In reservoirs where early summer drawdown results in a lack of vegetative cover, recruitment is likely to suffer (Aggus and Elliot 1975; Durocher et al. 1984; Ploskey 1986). Drawdown late in the summer may benefit bass by concentrating prey fish and making them more available (Keith 1975; Ploskey 1986). Fishery managers in Idaho typically have no control over the timing or degree of drawdown in irrigation reservoirs. Many of these waters, especially in southeastern Idaho, are virtually devoid of littoral cover after drawdown begins. We have no information on the effects of drawdown on largemouth bass recruitment in Idaho. Summer seeding in the fluctuation zones of smaller reservoirs may be a way to increase littoral cover the following spring, providing cover and increased food production for YOY bass (Ploskey 1986).

The predicted growth potential for largemouth bass in various areas of the state (Appendix I) can be used as a tool to help evaluate existing populations by comparing bass growth data to that in the graph for various Idaho Department of Fish and Game management areas. Average or better than average growth would mean the population is doing well given the thermal constraints of the water. Poorer than expected growth might indicate problems such as low water quality or competition. Poor growth could also indicate inappropriate or insufficient forage, as would likely occur in waters with established largemouth bass populations and no forage fish. While the predicted growth curves do not diagnose the problem, they can be used to help select waters for further evaluation. Efforts could then focus on problem populations, where growth might be improved.

Limitations of the Data

The primary problem in our attempts to relate forage and environment to largemouth bass growth is the limited data set and the range of conditions among existing populations. For example, there are no established largemouth bass-blue-gill fisheries in northern Idaho. As such, we have no indication of the utility of bluegill as forage in the colder and less productive waters of the state. The range of environmental and species composition data was more or less continuous, and the number of waters relatively small. Principle components analysis was not useful in classifying waters based on these data.

The bioenergetics analysis required that thermal regime be predicted in all study waters, but the validity of the predictor is unknown. The regression on original data was from only two waters. While the relationship between air temperature and water temperature is obvious, using air temperature alone to predict water temperature may be misleading. Other factors such as mean depth, exposure to wind, and water clarity may also influence thermal regime (Shuter et al. 1983). Errors in predicted temperature would lead to errors in estimates of forage availability and temperature-adjusted growth. The hot spring inflow to Pleasantview Reservoir probably results in warmer water temperatures than our model predicted. Despite the uncertainties, the model predictions are probably adequate to describe relative differences in thermal regime for most waters in the state.

I made the estimates of temperature-adjusted growth based on the assumption that forage availability for all age classes in a particular water would remain constant with an increase in water temperature. Changes in water temperature could, however, lead to changes in abundance or availability of some species, and would also affect predator consumption rates. Although our results did not indicate any differences in forage availability related to temperature or species composition, many species were primarily found in either the northern or southern parts of the state. As a result, it is unlikely that we could detect differences in species availability related to temperature, even if they occur.

For this analysis, we have assumed that largemouth bass populations in Idaho are typically held below carrying capacity by environmental constraints (Rieman 1987). Thus, we did not expect intraspecific competition to limit growth. Our temperature-adjusted growth data for most waters may support this (most waters have similar adjusted growth), but the data also suggest density-related effects for some waters. In waters with expanding populations (Deep Creek Reservoir and the Sand Dunes pond), bass growth was superior to that in nearby waters with established populations. Competition may be beginning to limit the growth of smaller bass in Deep Creek Reservoir as the population expands. Hauser Lake had higher bass catch rates and slower bass growth than similar nearby waters. We do not know what the range of bass densities is within Idaho, but at some point, competition may be important in some waters. The electrofishing catch rates used here as an index of largemouth bass abundance are probably not comparable across all waters because we sampled over several months. Information at this point is not sufficient to recommend any changes in statewide management but does warrant additional study.

CONCLUSIONS

Temperature appears to be the most important factor limiting largemouth bass growth in Idaho. Though forage type showed no obvious relationship to growth, it is reasonable to assume that some form of fish forage is a prerequisite for developing productive largemouth bass fisheries. Basing forage selection on the potential to develop a secondary fishery or provide some other benefit is a more valid parameter. Adding new forage species on top of an established forage community is not expected to improve largemouth bass growth.

For a given thermal regime, predator-prey balance may be more important than forage community per se in controlling largemouth bass growth. The predicted growth curves provided in this report can be used to judge existing populations. If a population has poorer than expected growth, further effort may be required to determine the cause.

If largemouth bass population densities are significantly lower in north Idaho than in south Idaho, we may be less able to manage the predator-prey balance through harvest regulations in north Idaho. The likelihood of developing stunted panfish populations where environmental constraints limit bass densities is high in these situations.

RECOMMENDATIONS

1) Consider introduction of forage species for largemouth bass only where the new species can provide a secondary fishery or other benefits. In northern Idaho, consider bluegill for use as largemouth bass forage only in waters with less than 30% macrophyte cover and relatively high bass densities. Restrict further bluegill introductions to north Idaho until evaluation of the past introductions are completed.

2) Largemouth bass-bluegill fisheries might best be managed for restricted bass harvest (length limits or catch-and-release) to keep bass densities high for desirable bluegill populations. This may be particularly important in north Idaho, where bass densities may be lower.

3) Use predicted growth curves developed for specific regions to evaluate largemouth bass growth rates. Limit efforts to improve bass growth to waters where growth is below average given the thermal regime for that region.

4) In drawdown reservoirs, consider summer seeding in the fluctuation zone to provide cover and increase food availability for YOY largemouth bass.

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A P P E N D I C E S

Appendix A. Physical and limnological characteristics of largemouth bass waters sampled throughout Idaho 1989-1990.

Location	Surface area (hectares)	Mean depth (m)	Conduct- ivity (mmhos/cm)	Total dissolved solids (mg/1)	MEI	Mean shoreline slope (degrees)	% surface area with vegetation (aquatic & emergent)	% shoreline with aquatic macrophyte cover	% shoreline with flooded terrestrial vegetation	% shoreline with flooded timber	%littoral zone with boulder cover	$\overline{X}$ annual air temp. (°C)	Eleva- tion (m)	Secchi disc trans parency (m)
Robinson Lake	24	9.9	37.2	25.2	1.60	22.7	15	11.9	6.8	52.5	0	6.7	806	4.8
Perkins Lake	24	2.9	82.0	54.4	4.35	15.6	20	91.2	8.8	5.9	0	6.7	803	2.9
Hauser Lake	223	6.1	47.4	31.8	2.88	11.2	5	53.5	3.5	0	8.6	9.1	667	2.6
Dawson Lake	14	4.0	57.0	38.6	3.12	29.0	20	100	0	61.0	0	6.5	902	2.3
Smith Lake	15	7.0	105.2	70.4	3.17	20.4	15	56.0	0	41.0	0	6.5	910	3.8
Fernan Lake	145	3.0	36.4	24.0	2.83	59.0	5	23.5	10.0	2.0	45.0	9.1	667	2.5
Blue Lake	136	3.6	46.4	31.6	2.96	21.5	15	40.0	0	10.0	22.0	9.1	625	2.6
Black Lake	162	4.6	116.0	82.7	4.24	-	10	-	-	-	-	9.1	697	-
Upper Twin Lake	203	2.4	21.6	15.4	2.53	19.0	20	11.6	6.6	0	27.0	9.1	703	2.6
Spring Valley Reservoir	21	4.3	31.2	22.8	2.30	26.7	5	76.7	0	3.3	16.6	7.4	915	2.7
Moose Creek Reservoir	20	.5	35.8	24.6	6.88	16.4	50	100	0	0	0	7.4	879	2.0
Mann Lake	49	4.7	83.8	58.2	3.54	25.0	0	0	0	0	0	11.2	552	1.8
Winchester Lake	34	3.4	134.6	90.2	5.12	26.3	5	23.3	0	12.0	10.0	8.6	1,190	1.0
Mann Creek Reservoir	113	10.0	131.8	90.0	3.00	31.5	1	1.0	25.0	0	43.8	9.2	934	2.1
C. Ben Ross Reservoir	143	6.7	82.0	54.8	2.85	25.4	1	21	13.0	46.0	2.6	8.5	960	1.1
Henning's Pond	3	3.0	262.8	176.2	7.66	30.0	5	50	50.0	0	0	12.5	648	0.7

29

Appendix A. Continued.

Location	Surface area (hectares)	Mean depth (m)	Conduct- ivity (mmhos/cm)	Total dissolved solids (mg/1)	MEI	Mean shoreline slope (degrees)	% surface area with vegetation (aquatic & emergent)	% shoreline with aquatic macrophyte cover	% shoreline with flooded terrestrial vegetation	% shoreline with flooded timber	%littoral zone with boulder cover	$\bar{X}$ annual air temp. (°C)	Eleva- tion (m)	Secchi disc trans parency (m)
Paddock Reservoir	607	3.0	106.8	72.4	4.90	20.0	20	93.4	0	0	34.2	8.5	970	0.6
Lake Lowell	4,050	5.2	194.6	129.6	4.97	5.0	5	70.0	30.0	0	0	10.6	772	0.6
Indian Creek Reservoir	90	3.4	231.0	154.2	6.75	10.0	20	70.0	0	0	0	10.3	1,007	0.5
Bruneau arm of C.J. Strike Reservoir	3,038	2.1	285.4	193.0	9.60	41.8	5	2.0	16.6	0	12.0	12.1	749	1.8
Crane Falls Reservoir	38	2.5	580	387.8	12.45	22.0	60	90.0	19.0	9.0	0	12.1	747	3.2
Sand Dunes Lake	41	2.5	1,382.0	919.0	19.17	15.3	5	0	55.8	2.3	0	12.1	800	4.2
Morrow Reservoir	19	5.1	112.6	75.4	3.28	19.3	20	21.0	32.0	68.0	8.0	10.3	860	0.6
Dog Creek Reservoir	24	2.5	372.8	251.0	5.39	21.1	30	90.0	6.0	38.0	20.0	9.8	1,091	1.2
Sumner Gravel Pond	1	2.5	764.0	512.0	14.30	60.0	1	0	80.0	0	0	10.6	904	0.7
Hagerman West Hwy 30 Pond	3	2.0	323.0	217.2	10.42	10.0	95	95.0	0	0	0	10.6	904	3.0
Lower Salmon Dam	340	-	503.6	335.4	-	41.0	-	90.0	0	0	46.6	10.6	854	2.8
St. Johns Reservoir	14	5.2	344.4	230.6	6.69	20.0	15	100	100	0	0	8.4	1,520	2.1
Pleasantview Reservoir	19	4.8	534.8	356.0	8.61	34.2	0	0	100	16.6	0	8.4	1,464	4.0

Appendix A. Continued.

Location	Surface area (hectares)	Mean depth (m)	Conduct-ivity (mmhos/cm)	Total dissolved solids (mg/1)	MEI	Mean shoreline slope (degrees)	% surface area with vegetation (aquatic & emergent)	% shoreline with aquatic macrophyte cover	% shoreline with flooded terrestrial vegetation	% shoreline with flooded timber	%littoral zone with boulder cover	$\bar{X}$ annual air temp. (°C)	Eleva-tion (m)	Secchi disc trans parency (m)
Condie Reservoir	47	5.1	255.0	170.8	5.80	21.6	35	89.2	40.5	0	0	8.1	1,490	3.0
Twin Lakes	181	9.5	234.8	159.8	4.09	21.4	5	16.2	40.5	0	0	8.1	1,453	2.7
Winder	38	5.4	171.6	115.8	4.63	67.1	15	100	0	0	0	8.1	1,487	-
Deep Creek Reservoir	74	7.5	324.2	218.4	5.39	25.1	0	0	39.5	0	8.0	7.4	1,572	3.6
Mud Lake	2,915	1.9	173.4	119.8	8.03	5.0	50	75.0	0	0	0	5.8	1,458	-

[a] From Apperson (1987).

31

Appendix B. Largemouth bass data and associated species in 34 Idaho waters sampled in 1989-1990.

Location	LMB electrofishing catch rate (fish/h)	LMB PSD	$\bar{X}$ Wr for LMB <300 mm	$\bar{X}$ Wr for LMB >300 mm	$\bar{X}$ LMB age at 200 mm	$\bar{X}$ LMB age at 300 mm	$\bar{X}$ LMB age at 400 mm	Associated species[a]
Robinson Lake	-	-	-	-	3.0	4.B	7.3	PMS,BBH,HRB
Perkins Lake	-	-	-	-	2.8	4.6	7.5	PMS,BCR,BKT,SU
Hauser Lake	78.0	20	100.0	110.8	4.1	7.3	-	PMS,BCR,YEP,BBH,TEN,HRB
Dawson Lake	1.3	0	102.0	103.0	2.3	4.2	-	PMS,YEP,BCR,BBH
Smith Lake	74.0	2	104.0	-	3.5	-	-	BBH,HRB
Fernan Lake	-	-	107.0	109.0	3.1	5.0	7.6	PMS,TEN,BCR,YEP
Blue Lake	36.0	79	104.0	95.0	2.4	3.8	-	PMS,YEP,BCR,BBH,TEN,NOP
Black Lake	42.7	33	108.0	103.0	2.5	3.7	5.4	PMS,YEP,BCR,BBH,TEN,NOP
Upper Twin Lake	26.0	52	96.0	108.0	3.5	5.4	7.2	PMS,YEP,BCR,BBH,SU,TEN
Spring Valley Reservoir	-	-	106.1[a]	105.0[a]	3.6	-	-	HRB
Moose Creek Reservoir	-	-	106.4[a]	109.0[a]	3.2	5.3	-	PMS,BBH,SU,HRB
Mann Lake	171.0	1	95.0	-	4.0	-	-	PMS,BCR,SU,HRB
Winchester Lake	-	-	-	-	2.2	3.5	5.4	BBH,HRB
Mann Creek Reservoir	51.0	2	112.2	102.6	2.3	-	-	BCR,SU,WRB,HRB
C. Ben Ross Reservoir	84.0	31	110.0	100.0	1.7	4.6	-	BCR,SU,CAR

Appendix B. Continued.

Location	LMB electrofishing catch rate (fish/h)	LMB PSD	$\bar{X}$ Wr for LMB <300 mm	$\bar{X}$ Wr for LMB >300 mm	$\bar{X}$ LMB age at 200 mm	$\bar{X}$ LMB age at 300 mm	$\bar{X}$ LMB age at 400 mm	Associated speciesa
Henning's Pond	127.0	48	8B	85	2.0	3.4	5.1	BLG
Paddock Reservoir	102.8	B	109.2	110.3	2.4	4.6	-	BCR,BBH
Lake Lowell	-	-	-	-	2.1	3.2	5.6	BLG,YPE,RSS,SU,CAR
Indian Creek Reservoir	22.5	33	104.0	107.0	2.6	4.7	-	BLG,BCR,BBH
Bruneau arm of C.J. Strike Reservoir	9.8	62	111.0	106.0	1.7	2.7	4.9	BLG,PMS,YEP,BCR,CHS,SQF,RSS, SMB, BBH,SU,CAR
Crane Falls Reservoir	112.5	1	91.0	-	2.8	-	-	BLG, PMS, BBH
Sand Dunes Lake	49.9	59	115.0	108.0	1.4	-	-	BLG,PMS
Morrow Reservoir	98.2	62	104.0	100.0	2.5	5.4	7.5	BLG,BCR,YEP,BBH,HRB
Dog Creek Reservoir	46.0	44	115.5	110.5	3.4	4.6	6.4	BLG,YEP,RSS,SU,CAR,HRB
Sumner Gravel Pond	112.0	35	92.0	100.0	2.0	3.5	5.0	BLG,CAR
Hagerman West Hwy 30 Pond	50.0	55	106.9	92.1	2.1	3.3	4.3	BLG,BBH
Lower Salmon Dam	12.0	70	129.5	129.3	2.3	3.4	-	BLG,YEP,RSS,LND,SU,CAR
St. Johns Reservoir	90.0	5	92.0	121.0	3.2	-	-	BLG,YEP,HRB
Pleasantview Reservoir	214.0	63	127.0	127.0	2.0	3.2	4.6	UTC,RSS,HRB

33

Appendix B. Continued.

Location	LMB electrofishing catch rate (fish/h)	LMB PSD	$\bar{X}$ Wr for LMB <300 mm	$\bar{X}$ Wr for LMB >300 mm	$\bar{X}$ LMB age at 200 mm	$\bar{X}$ LMB age at 300 mm	$\bar{X}$ LMB age at 400 mm	Associated species[a]
Condie Reservoir	-	-	-	-	2.3	4.5	7.1	BLG,YEP
Twin Lakes	-	-	-	-	2.3	4.7	7.1	BLG,BBH,CAR,HRB
Winder	-	-	-	-	2.7	5.1	-	GSF,HRB
Deep Creek Reservoir	104.0	77	120.9	107.9	1.6	2.8	-	HRB,WCT
Mud Lake	24.0	70	124.5	118.1	3.5	6.4	9.7	YEP,BCR,UTC,SU

[a]PMS = pumpkinseed, BBH = brown bullhead, HRB = hatchery rainbow trout, BCR = black crappie, BKT = brook trout, SU = sucker spp., YEP = yellow perch, TEN = tench, NOP = northern pike, WRB = wild rainbow trout, CAR = carp, BLG = bluegill, RSS = redside shiner, CHS = chiselmouth, SQF = northern squawfish, SMB = smallmouth bass, LND = longnose dace, UTC = Utah chub, WCT = wild cutthroat trout.

Appendix C. Summary of weighted mean lengths-at-annulus (mm) for largemouth bass from Idaho waters, 1989-1990.

Location	Length-at-annulus I	II	III	IV	V	VI	VII	VIII	IX
Robinson Lake[a]	65	129	201	265	308	346	387	426	446
Perkins Lake[a]	72	146	212	273	316	346	382	420	426
Hauser Lake	67	119	159	196	224	251	288	327	347
Dawson Lake	89	179	240	289	337	352	-	-	-
Smith Lake	70	137	191	210	237	253	-	-	-
Fernan Lake[a]	67	136	194	249	299	343	381	411	437
Blue Lake	76	169	245	310	341	372	-	-	-
Black Lake	71	165	238	328	384	429	449	466	483
Upper Twin Lake	72	128	176	224	281	331	393	432	455
Region 1 Mean	72	145	206	260	303	325	380	414	432
Spring Valley Reservoir[b]	58	116	168	221	-	-	-	-	-
Moose Creek Reservoir[b]	72	127	182	255	286	332	-	-	-
Mann Lake	85	130	168	201	223	284	-	-	-
Winchester Lake	91	181	261	338	385	419	437	-	-
Region 2 Mean	77	139	195	254	298	345	-	-	-
Mann Creek Reservoir	81	179	254	266	-	-	-	-	-
Lake Lowell[c]	91	195	290	342	383	412	440	455	468

Appendix C. Continued.

Location	Length-at-annulus								
	I	II	III	IV	V	VI	VII	VIII	IX
Paddock Reservoir	86	176	235	261	333	-	-	-	-
Henning's Pond (Weiser)	93	204	276	339	393	455	-	-	-
C. Ben Ross Reservoir	120	241	273	283	312	365	-	-	-
C.J. Strike Reservoir	99	236	323	351	405	454	-	-	-
Crane Falls Reservoir	82	157	211	248	-	-	-	-	-
Indian Creek Reservoir	93	146	238	263	315	-	-	-	-
Region 3 Mean	93	192	263	294	357	422	-	-	-
Hagerman West Hwy 30 Pond[d]	95	194	272	385	442	471	522	534	-
Dog Creek Reservoir	70	130	167	248	313	349	-	-	-
Lower Salmon Dam	90	173	268	346	-	-	-	-	-
Sumner Gravel Pond	101	198	263	333	400	422		-	-
Morrow Reservoir	92	179	221	255	290	314	359	429	-
Sand Dunes Lake	132	286	-	-	-	-	-	-	-
Region 4 Mean	97	193	238	313	361	369	441	482	-
Winder Reservoir[e]	76	164	218	269	295	331	370	-	-

Appendix C. Continued.

Location	Length-at-annulus								
	I	II	III	IV	V	VI	VII	VIII	IX
Deep Creek Reservoir	127	257	314	-	-	-	-	-	-
Twin Lakes[e]	130	187	236	277	311	352	398	426	451
Condie Reservoir[e]	129	188	239	278	327	361	398	431	450
Pleasantview Reservoir	102	202	287	366	424	472	489	499	512
St. John's Reservoir	86	129	191	246	-	-	-	-	-
Region 5 Mean	108	188	248	287	339	379	414	452	471
Mud Lake[f]	63	104	169	229	260	290	318	346	376

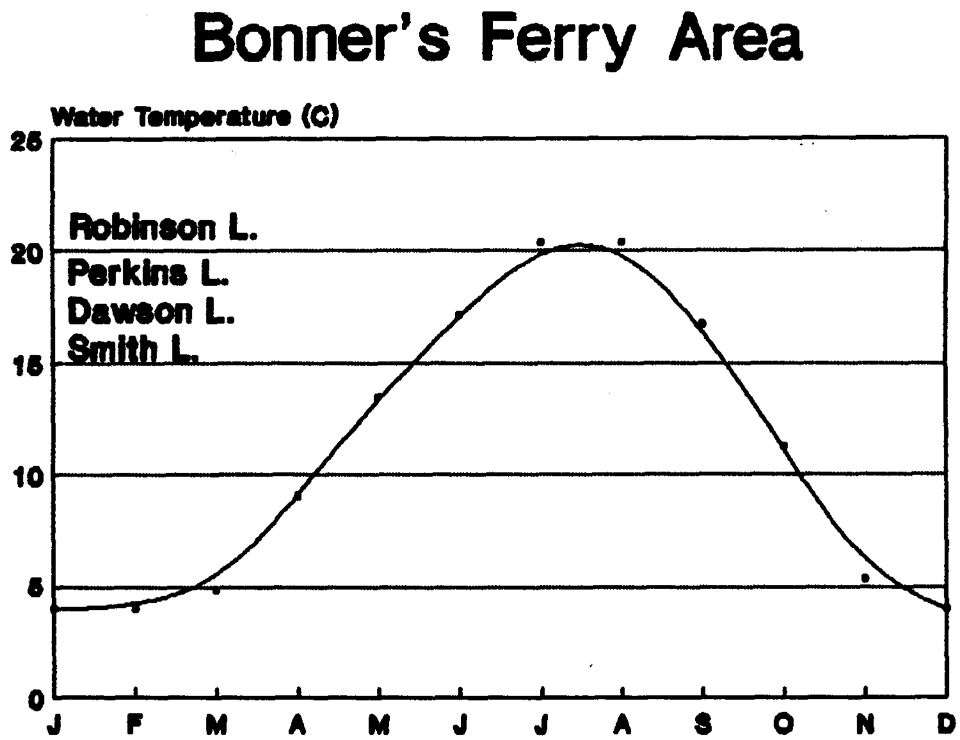
[a]Rieman 1987.
[b]Apperson 1987.
[c]holubetz and Mabbott 1988.
[d]Bell and Grunder 1987.
[e]La Bolle and Schill 1989.
[f]Elle and Corsi 1984.

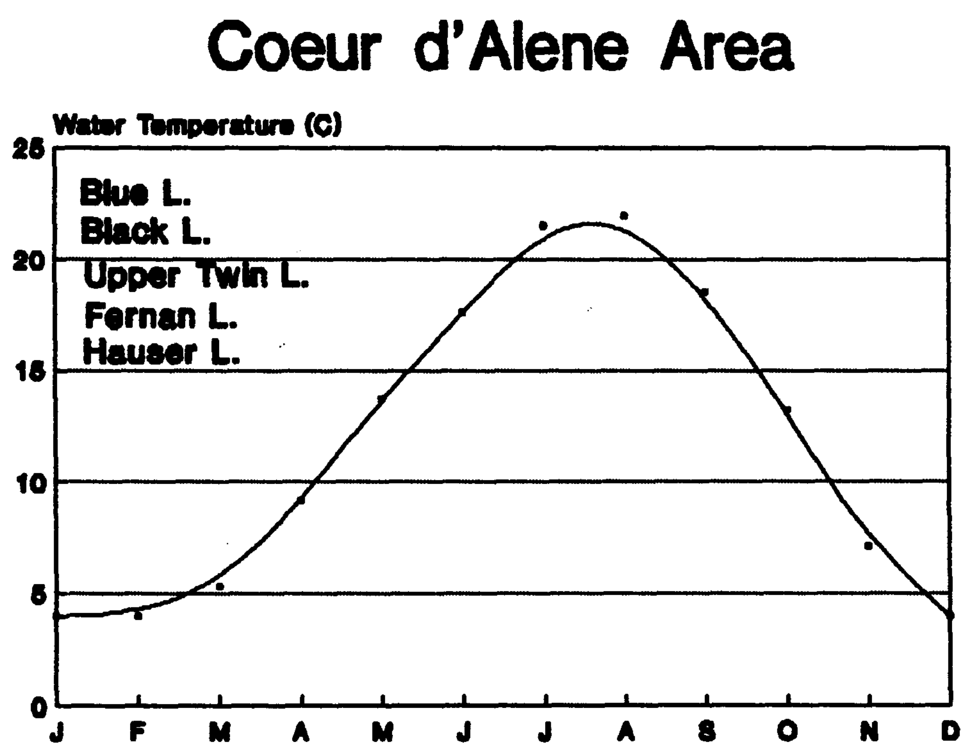
Appendix D. Select results of correlation analysis of largemouth bass age-at-length, lake conductivity, and mean annual air temperature (TEMP) data from 34 Idaho lakes, 1989-1990.

	Conductivity	TEMP
Age at 200 mm	-.482	-.325
Age at 300 mm	-.530	-.419
Age at 400 mm	-.544	-.641
Conductivity	-	.481

Appendix E. Results of regression analyses with the independent variables mean annual air temperature (TEMP) and conductivity and dependent variables largemouth bass age at 200, 300, or 400 mm.

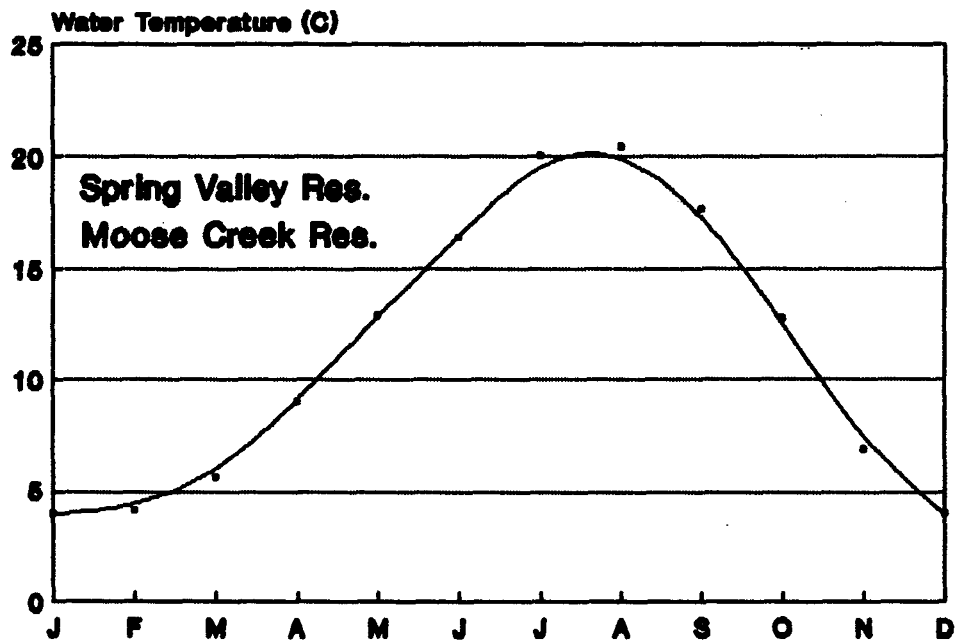
Dependent variable	Independent variable	Coefficient	Probability of contribution. to the model	R^2
	Constant	3.368	0.000	
LMB age at 200 mm	Conductivity	-0.001	0.026	.245
	TEMP	-0.052	0.483	
	Constant	6.728	0.000	
LMB age at 300 mm	Conductivity	-0.003	0.020	.353
	TEMP	-0.199	0.123	
	Constant	10.983	0.000	
LMB age at 400 mm	Conductivity	-0.003	0.044	.564
	TEMP	-0.434	0.011	



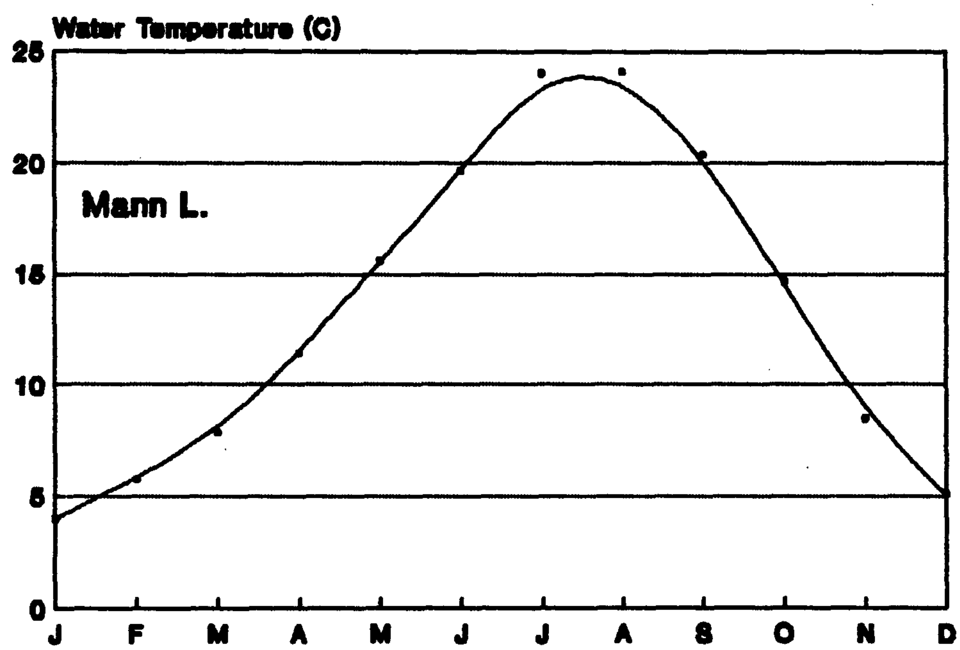


Appendix F. Predicted thermal regimes for lakes and reservoirs in various geographical regions of Idaho and associated study waters.

Moscow Area

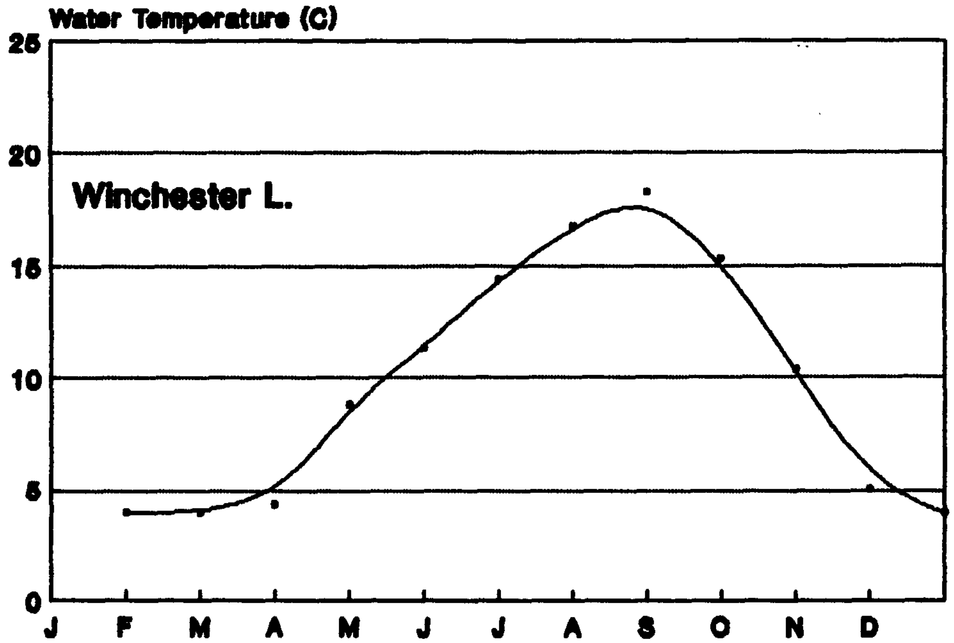


Lewiston Area

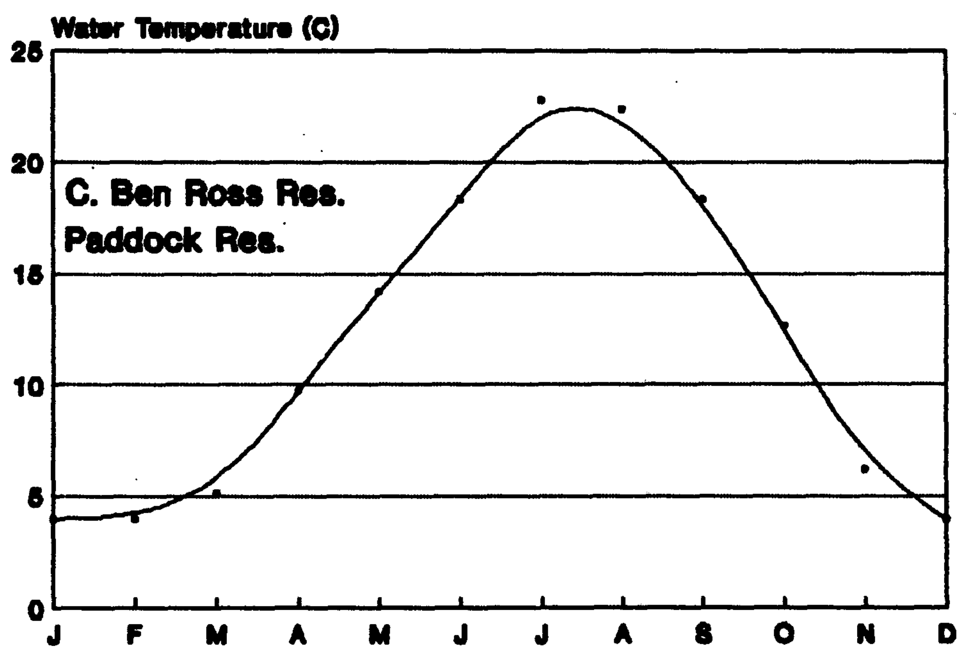


Appendix F. Continued.

Craigmont Area

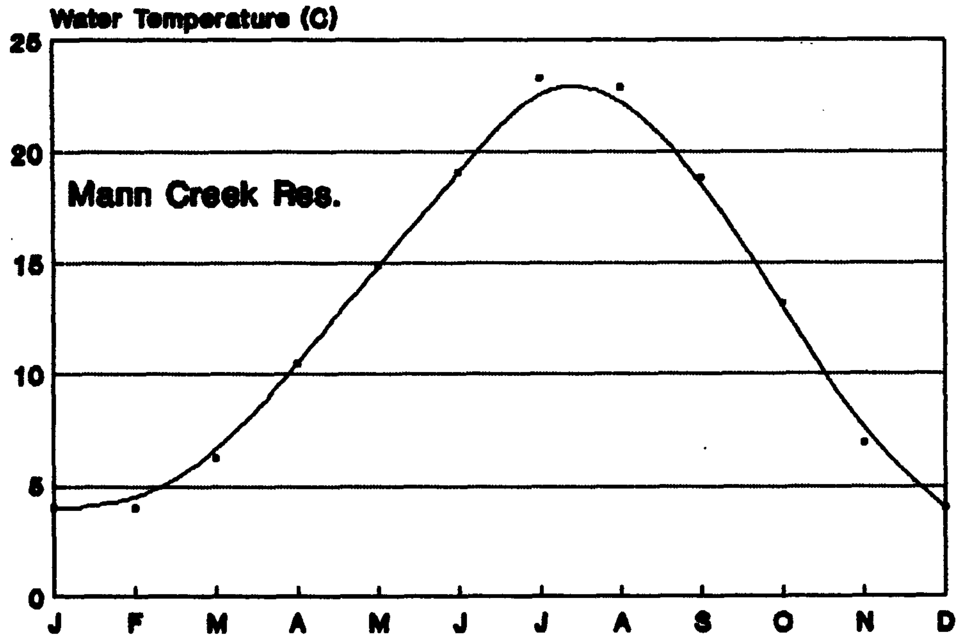


Cambridge Area

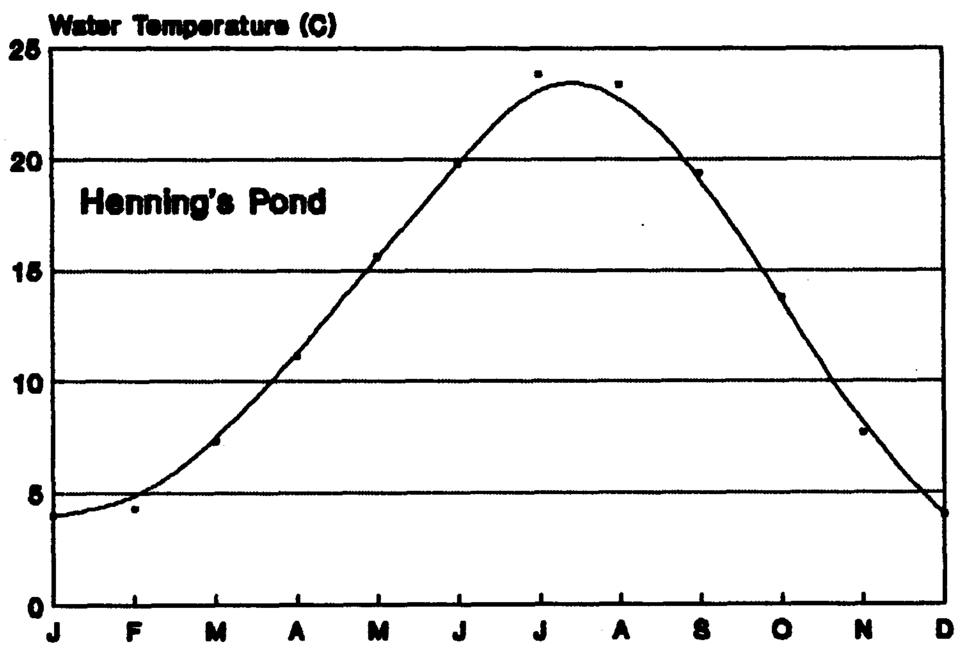


Appendix F. Continued.

Council Area



Weiser Area



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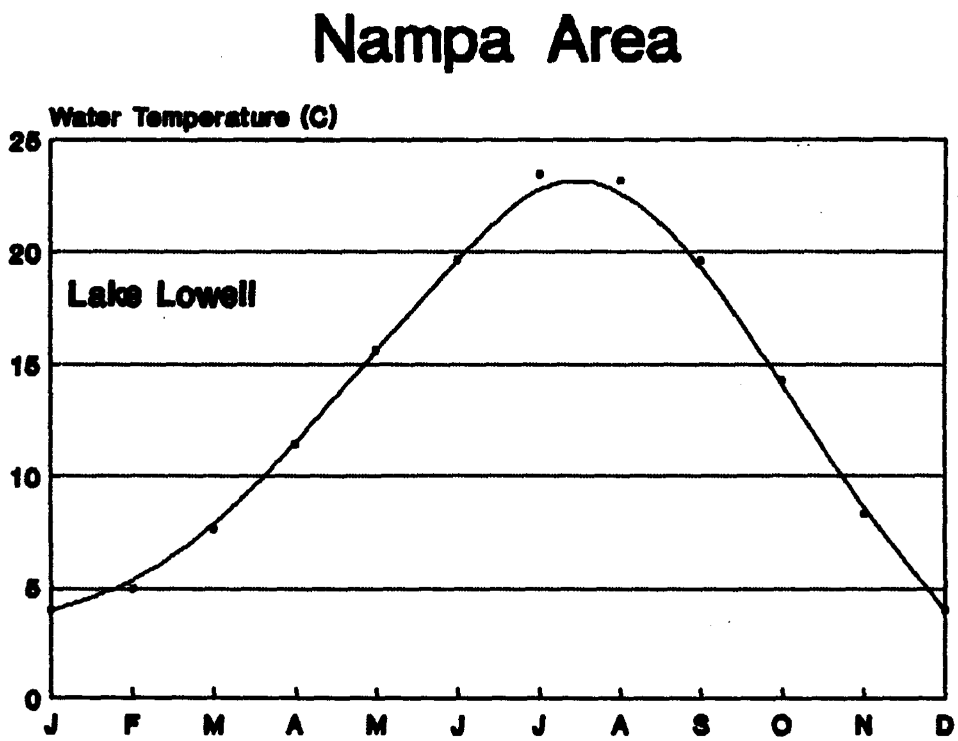
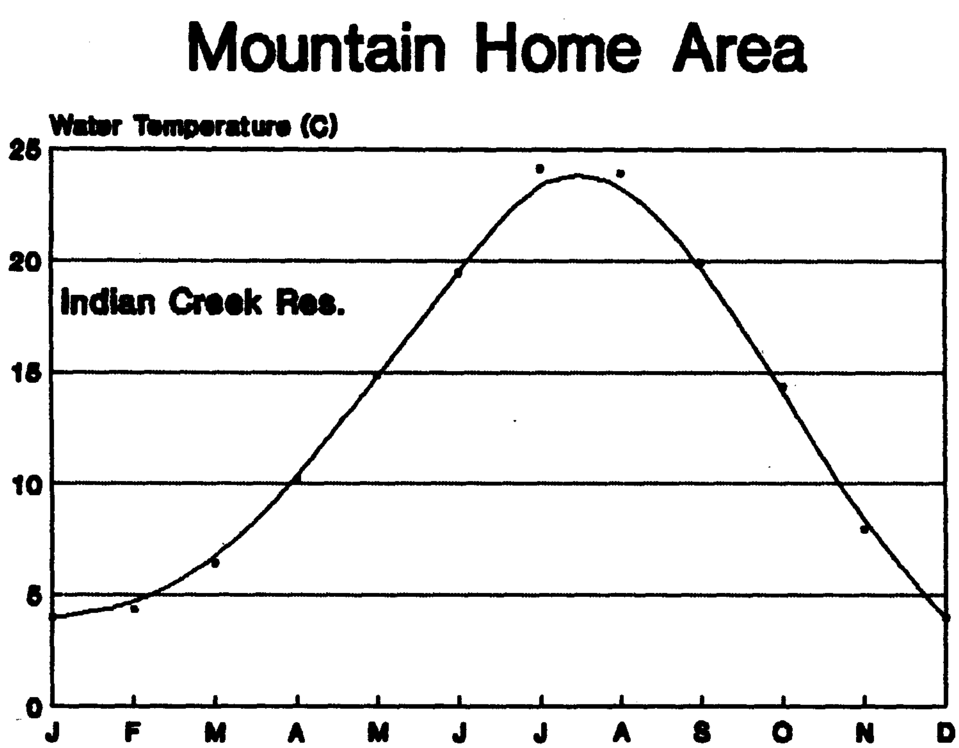
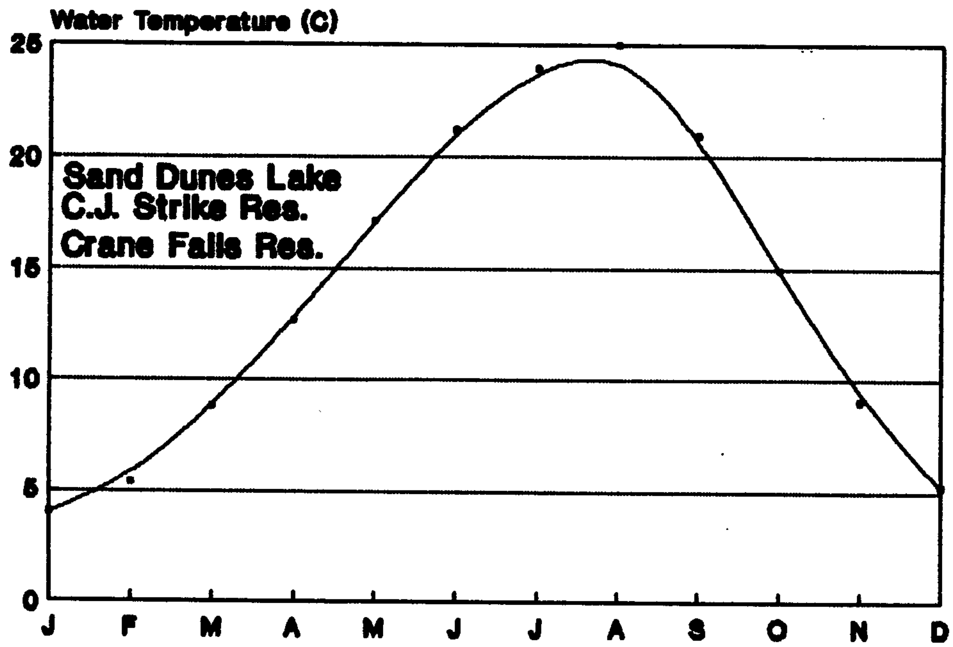


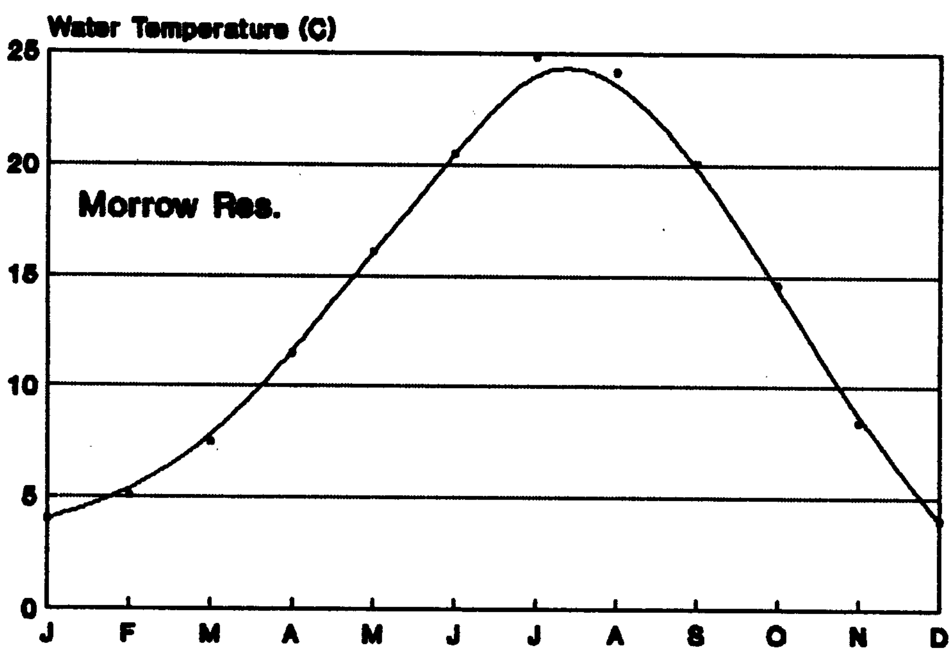


Appendix F. Continued.

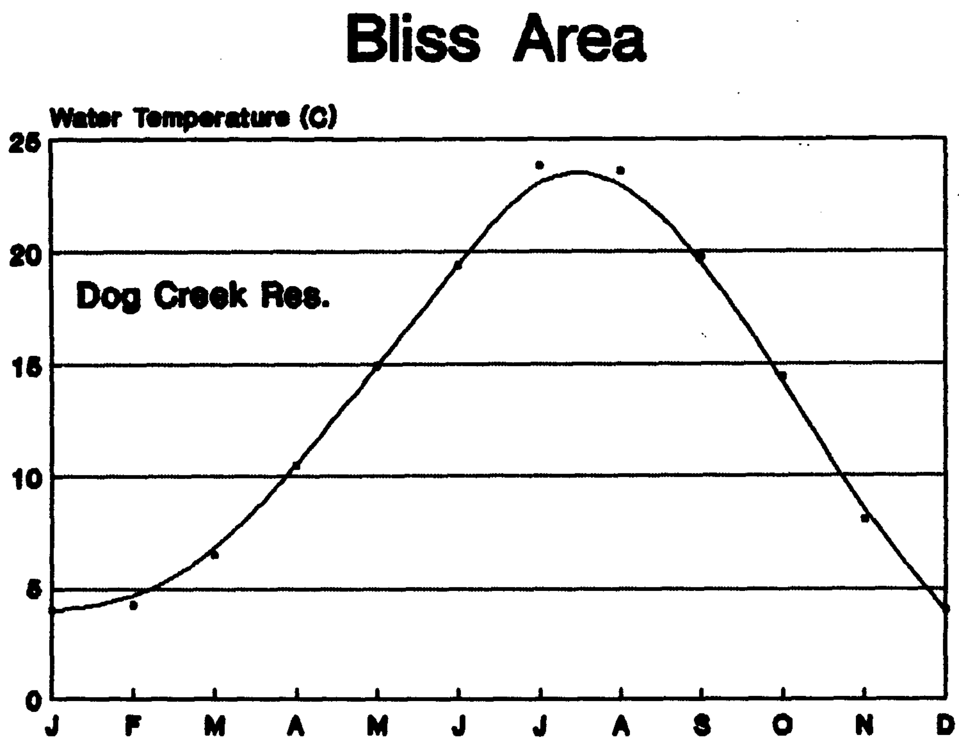
Bruneau Area

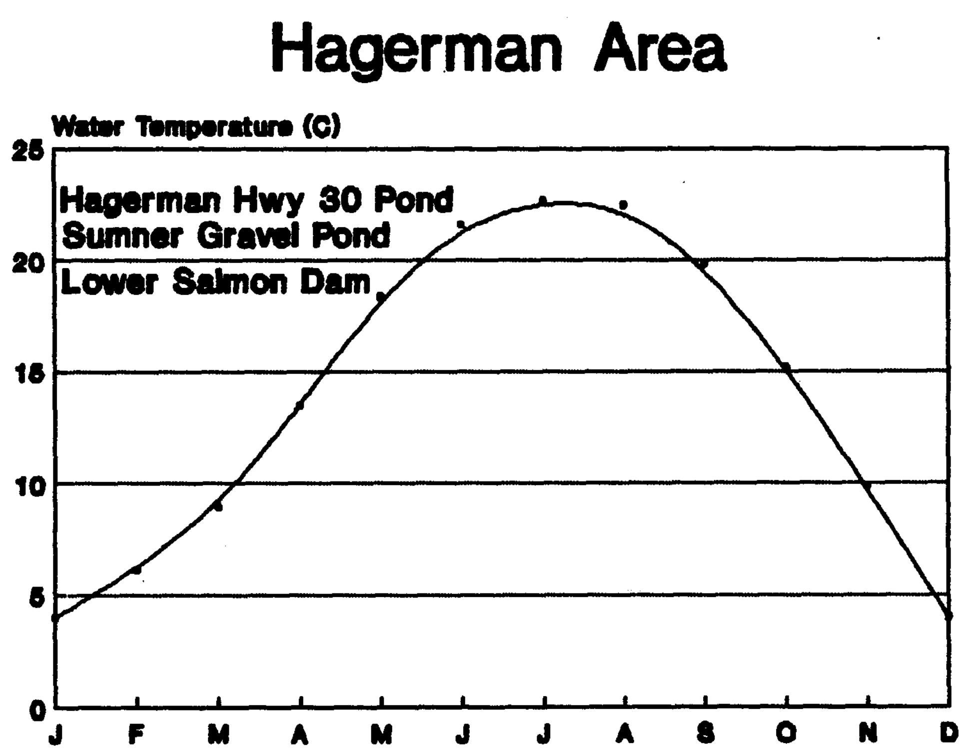


Glenn's Ferry Area



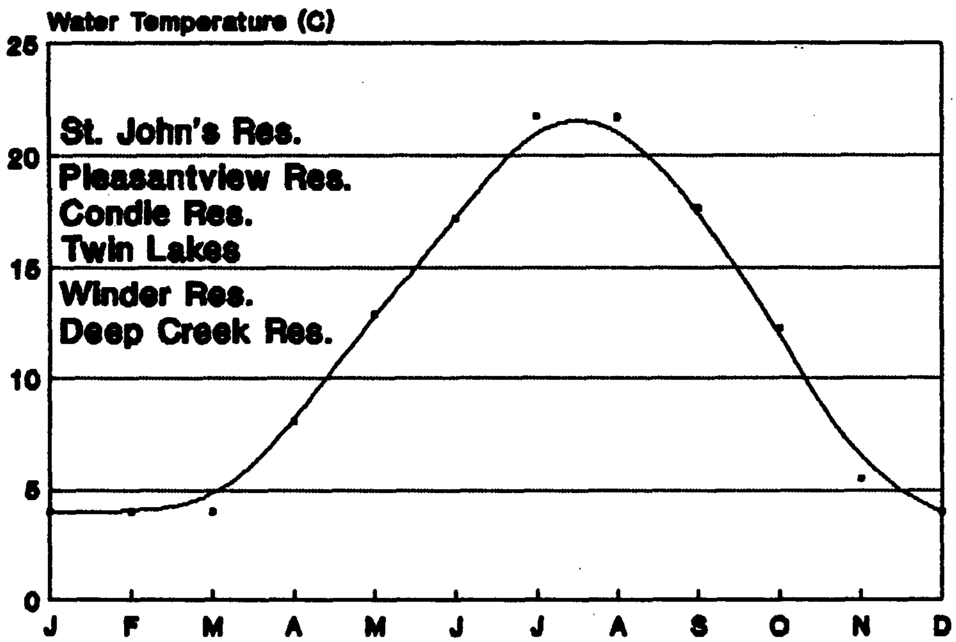
Appendix F. Continued.



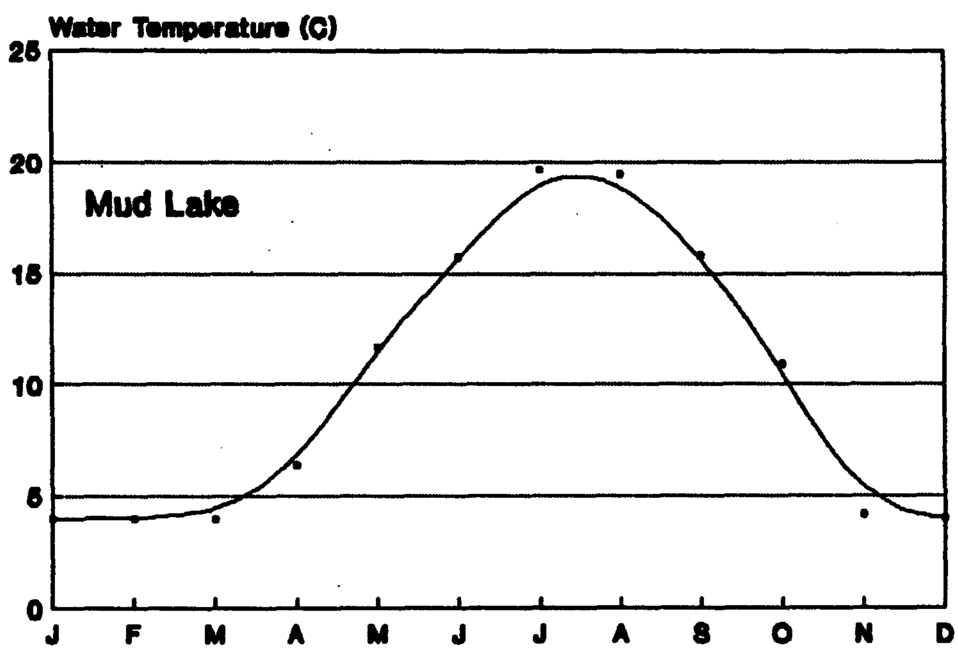


Appendix F. Continued.

Malad City Area



St. Anthony Area



Appendix F. Continued.

Appendix G. Indices of forage availability (p-values), by cohort, for Idaho largemouth bass populations sampled statewide, 1989-1990.

Location	Cohort P-values									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Robinson Lake	-	.573	.584	.473	.490	.467	.480	.475	.404	-
Perkins Lake	-	.603	.561	.424	.505	.446	.452	.470	.353	-
Hauser Lake	-	.533	.466	.435	.404	.418	.431	.423	.383	-
Dawson Lake	-	.642	.545	.497	.491	.377	-	-	-	-
Smith Lake	-	.598	.515	.407	.431	.396	.374	-	-	-
Fernan Lake	-	.552	.508	.488	.464	.463	.379	.416	-	-
Blue Lake	-	.559	.535	.505	.388	.429	-	-	-	-
Black Lake	-	.615	.556	.563	.480	.456	.354	.374	.365	.426
Upper Twin Lake	-	.506	.486	.538	.465	.472	.511	.408	.361	.363
Spring Valley Reservoir	-	.556	.594	.425	-	-	-	-	-	-
Moose Creek Reservoir	-	.543	.548	.553	.435	.479	-	-	-	-
Mann Lake	-	.443	.415	.381	.379	.513	-	-	-	-
Winchester Lake	-	.674	.625	.610	.500	.453	.395	-	-	-
Mann Creek Reservoir	-	.633	.492	.338	-	-	-	-	-	-
C. Ben Ross Reservoir	-	.683	.413	.349	.393	.459	-	-	-	-
Henning's Pond	-	.599	.459	.457	.426	.486	-	-	-	-
Paddock Reservoir	-	.645	.460	.400	.506	-	-	-	-	-

Appendix G. Continued.

Location	Cohort P-values									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Lake Lowell	-	.589	.533	.442	.412	.395	.354	.341	.338	-
Indian Creek Reservoir	-	.437	.616	.380	.425	-	-	-	-	-
Bruneau arm of C.J. Strike Reservoir	-	.658	.476	.364	.394	.394	-	-	-	-
Crane Falls Reservoir	-	.495	.428	.382	-	-	-	-	-	-
Sand Dunes Lake	-	.656	-	-	-	-	-	-	-	-
Morrow Reservoir	-	.548	.397	.403	.377	.367	.402	.462	-	-
Dog Creek Reservoir	-	.491	.423	.514	.496	.348	-	-	-	-
Sumner Gravel Pond	-	.526	.445	.479	.462	.353	-	-	-	-
Hagerman West Hwy 30 Pond	-	.537	.484	.539	.454	-	-	-	-	-
Lower Salmon Dam	-	.542	.529	.479	-	-	-	-	-	-
St. John's Reservoir	-	.488	.536	.504	-	-	-	-	-	-
Pleasantview Reservoir	-	.698	.609	.585	.506	.470	.357	.326	.364	-
Condie Reservoir	-	.530	.497	.455	.483	.433	.440	.425	.378	.429
Twin Lakes	-	.643	.484	.415	.430	.492	.491	.404	.399	-
Winder Reservoir	-	.627	.492	.463	-	-	-	-	-	-

Appendix G. Continued.

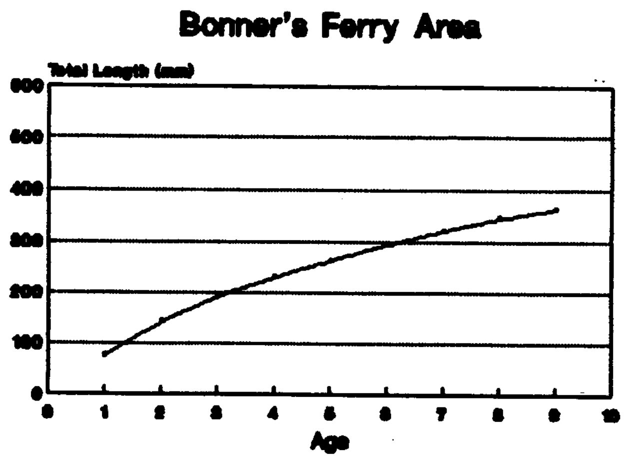
Location	Cohort P-values									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Deep Creek Reservoir	-	.757	.499	-	-	-	-	-	-	-
Mud Lake	-	.539	.611	.581	.470	.462	.453	.449	.454	-
Statewide Average		.580	.510	.463	.449	.436	.420	.415	.380	.406

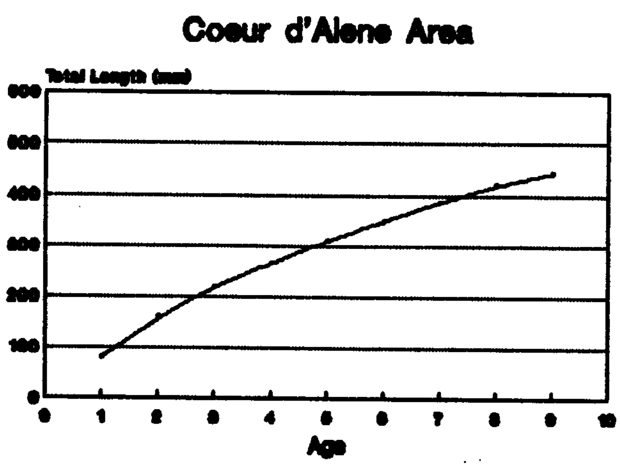
Appendix H. Temperature-adjusted length-at-age (mm) for Idaho largemouth bass populations sampled statewide, 1989-1990.

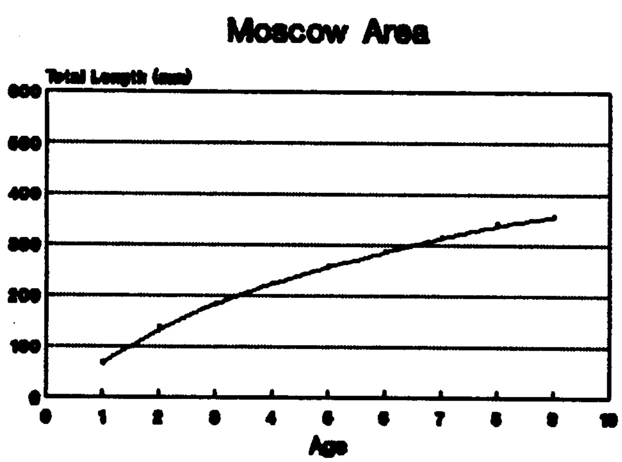
	length-at-age							
Location	I	II	III	IV	V	VI	VII	VIII
Robinson Lake	65	179	323	393	475	560	-	-
Perkins Lake	72	201	316	373	469	539	-	-
Hauser Lake	67	159	229	287	334	389	451	-
Dawson Lake	89	239	350	430	532	-	-	-
Smith Lake	70	195	291	340	400	446	-	-
Fernan Lake	67	170	261	346	422	500	-	-
Blue Lake	76	209	314	408	451	514	-	-
Black Lake	71	205	320	441	528	-	-	-
Upper Twin Lake	72	152	232	339	415	497	-	-
Spring Valley Reservoir	58	164	295	352	-	-	-	-
Moose Creek Reservoir	72	173	283	398	454	549	-	-
Mann Lake	85	136	180	210	241	337	-	-
Winchester Lake	91	256	405	549	-	-	-	-
Mann Creek Reservoir	81	226	311	328	-	-	-	-
C. Ben Ross Reservoir	120	291	345	368	412	487	-	-
Henning's Pond	93	223	293	365	424	513	-	-
Paddock Reservoir	86	236	307	353	449	-	-	-
Lake Lowell	91	214	319	384	438	485	514	-
Indian Creek Reservoir	93	142	282	317	375	-	-	-

Appendix H. Continued.

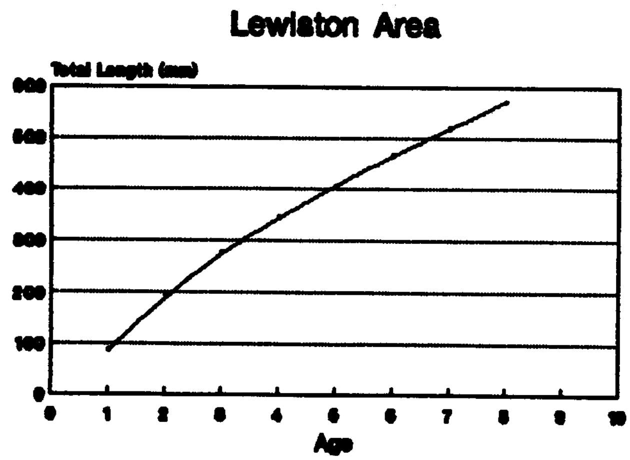
Location	Length-at-age							
	I	II	III	IV	V	VI	VII	VIII
Bruneau arm of C.J. Strike Reservoir	99	236	323	351	405	454	-	-
Crane Falls Reservoir	82	157	211	248	-	-	-	-
Sand Dunes Lake	132	286	-	-	-	-	-	-
Morrow Reservoir	92	197	236	279	313	344	391	468
Dog Creek Reservoir	70	143	191	285	375	398	-	-
Sumner Gravel Pond	101	194	256	336	411	439	-	-
Hagerman West Hwy 30 Pond	95	194	275	384	457	-	-	-
Lower Salmon Dam	90	191	292	374	-	-	-	-
St. John's Reservoir	86	160	263	355	-	-	-	-
Pleasantview Reservoir	102	278	420	553	-	-	-	-
Condie Reservoir	129	220	307	378	465	530	-	-
Twin Lakes	130	240	323	375	437	528	-	-
Winder Reservoir	76	217	302	377	-	-	-	-
Deep Creek Reservoir	127	332	424	-	-	-	-	-
Mud Lake	63	160	299	428	509	-	-	-

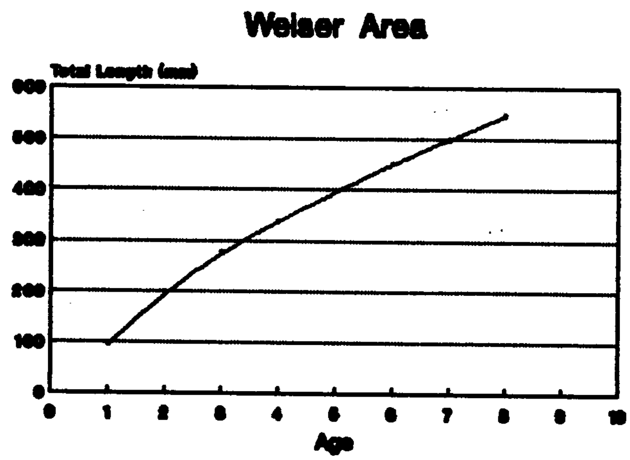


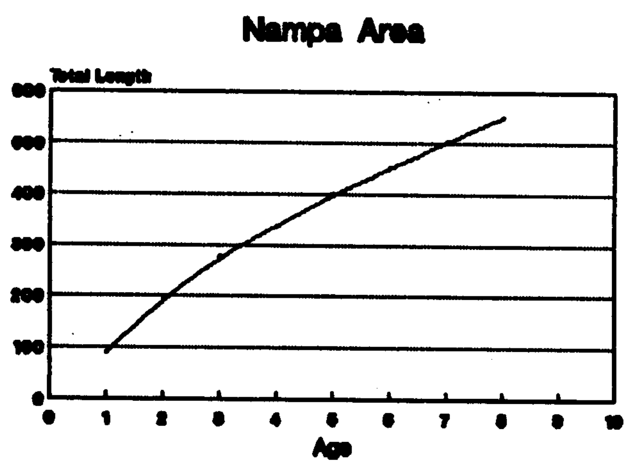




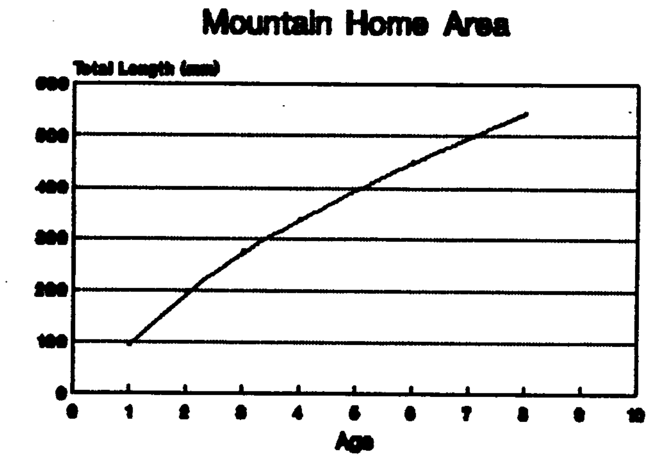
Appendix I. Predicted growth of largemouth bass in various geographical areas of Idaho based on regional temperatures and statewide average forage availability.

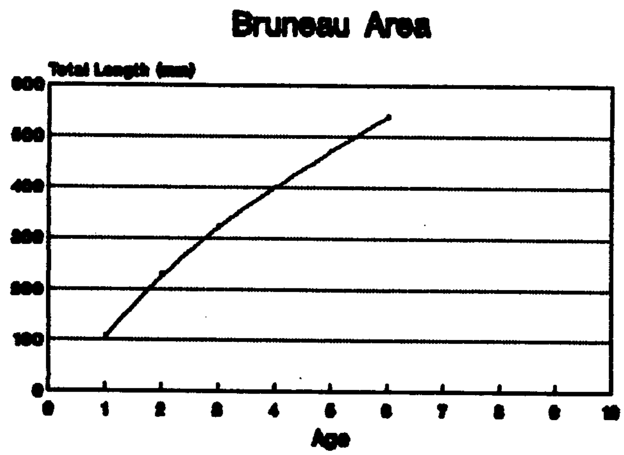


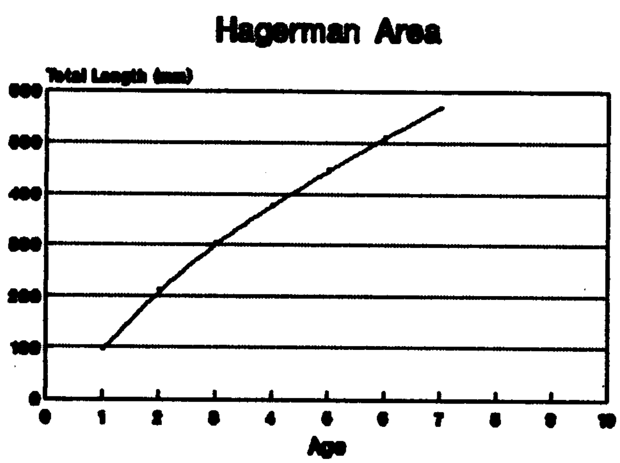




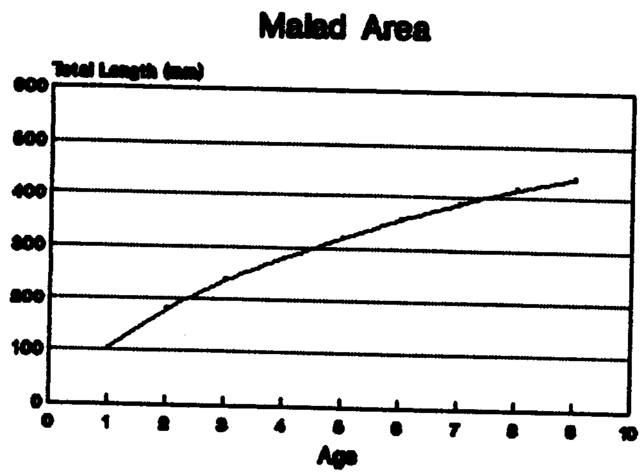
Appendix I. Continued.

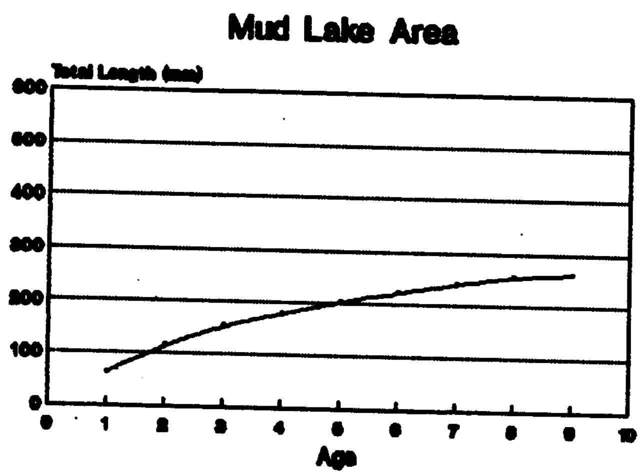






Appendix I. Continued.





Appendix I. Continued.

Appendix J. Comparison of largemouth bass growth variability for 34 Idaho waters statewide with and without outliers, and for temperature-adjusted growth with and without outliers.

	Mean age (yrs)	Coefficient of variation
Unadjusted growth (all waters)		
Age at 200 mm	2.61	26.58
Age at 300 mm	4.35	24.94
Age at 400 mm	6.33	22.83
Unadjusted growth (outliers deleted)		
Age at 200 mm	2.65	24.40
Age at 300 mm	4.46	24.21
Age at 400 mm	6.44	23.71
Temperature-adjusted growth (all waters)		
Age at 200 mm	2.08	22.84
Age at 300 mm	3.20	22.78
Age at 400 mm	4.63	18.38
Temperature-adjusted growth (outliers deleted)		
Age at 200 mm	2.05	14.63
Age at 300 mm	3.07	13.36
Age at 400 mm	4.44	13.06

Appendix K. Mean length-at-annulus (mm) for largemouth bass from Deep Creek Reservoir, July 1989.

Year Class	n	Length at annulus		
		I	II	III
1987	8	113.6	225.3	
1986	20	133.2	270.5	314.2

Submitted by:

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Steven M. Huffaker, Chief
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